STRUCTURAL DYNAMICS OF BOREAL FOREST ECOSYSTEMS ON THREE HABITAT TYPES IN THE HONDO - LESSER SLAVE LAKE AREA OF NORTH CENTRAL ALBERTA IN 1981[a]

Report OF-64

RESEARCH MANAGEMENT DIVISION
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STRUCTURAL DYNAMICS OF BOREAL FOREST ECOSYSTEMS ON THREE HABITAT TYPES IN THE HONDO - LESSER SLAVE LAKE AREA OF NORTH CENTRAL ALBERTA IN 1981[a]

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RMD-80/35A

and

RECREATION, PARKS AND WILDLIFE
FOUNDATION

April 1982

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[a] Contribution No. 1 of the SEADYN Project.

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ABSTRACT

The primary purpose of the SEADYN project is to intensively study and document the short- and long-term structural dynamics of the plant community components of eight boreal forest ecosystems representing different successional stages on three important habitat types in the Southern Boreal Forest Subzone of north central Alberta. Nineteen hypotheses and 14 objectives indicate the scope and intensity of the project.

Eight 50 x 50 m reference stands were established and surveyed in the Hondo - Lesser Slave Lake area in 1980, including four on the *Picea glauca* [*Pinus banksiana*] habitat type on aeolian sand, two on the *Picea glauca* [*Populus tremuloides*] habitat type on glacial till, and two on the *Picea mariana* [*Larix laricina*] habitat type on peatland. Each stand is grid-staked into 100 5 x 5 m sampling units with alternating rows of study and control units.

Five years of intensive, non-disruptive measurements of intraseasonal, seasonal, annual and long-term successional variations of some important vascular plant and terrestrial bryoid population and community attributes in the reference stands began in 1981. Observations included: plant cover (%) at monthly intervals; allometric estimates of vascular leaf area (m^2 ha^{-1}) and above-ground live biomass (kg ha^{-1}); phenological surveys of live tagged and collected vascular plants; stem-mapping of tree populations; measurements of atmospheric and soil environmental variables; and time-lapse photography of permanent microplots in the stands. This report describes and discusses some of the results of the first complete study season.

The 1981 snow-free season was longer, cooler and drier than average, with May and August very dry and July very wet. Snowshoe Hares caused considerable browse damage to their preferred shrub and tree species during the winter of 1980-81; Tent Caterpillars defoliated *Populus tremuloides* and other preferred food species in late May and early June.

Forests of the *Picea glauca* [*Populus tremuloides*] habitat type were much more 'dynamic' in terms of changes in vascular plant shoot cover than were those of the other two habitat types during the 1981 snow-free season. Several dominant vascular plant species showed significant decreases in cover from 1980 to 1981, including species unaffected by herbivores. Plant species varied widely in the magnitude of their dynamic variation in cover, and also in their ability to recover after perturbations, e.g., defoliation and drought. Regression equations for the estimation of above-ground live biomass and leaf area from live shoot cover of understory vascular species seem sufficiently accurate to give reliable projections of biomass and leaf area dynamics in the reference stands.

Feather moss cover increases while the cover of other terrestrial bryophyte and lichen growth-forms decreases during plant succession on all three habitat types. The total cover of herbaceous and broad-leaf deciduous vascular plants increases during early successional stages but then decreases in later stages such that needle- and broad-leaf evergreen vascular plants dominate the subclimax and climax forests of all three habitat types.

ACKNOWLEDGEMENTS

We extend our sincere thanks to Mr. Robert Ellis, Mr. Peter Farrington, Mr. Larry Flanagan, and Mr. Bill Lee of the University of Alberta for outstanding performance of their appointed field and laboratory responsibilities at Hondo during the summer of 1981, and to Mrs. Nancy La Roi for equally dedicated work on the dimensional attributes of plant specimens in the laboratory at Edmonton during the winter of 1981-82; their contribution was absolutely crucial to the success of the project. We also thank Mr. Wayne Strong, Mr. Ross Hastings, and Ms. Renee La Roi, who provided additional help during periods of peak demand.

We gratefully acknowledge the assistance of Mr. Carson McDonald and the staff of the Slave Lake Forest, Alberta Department of Energy and Natural Resources, for their co-operation and assistance in 1981-82. We thank the Alberta Natural Areas Committee for permission to conduct research in four permanent plots located in Educational Natural Areas of the Boreal Forest Region; and also the Forest Research Branch, Alberta Department of Energy and Natural Resources for placing protective reservations on lands enclosing four other permanent plots in the study area. We thank Mr. Geoff Lester and the cartographic staff of the Department of Geography for preparing the map of the study area.

Many other individuals, including Dr. Walter Moser and Dr. Percy Sims, gave us helpful advice.

The SEADYN Project was made possible by generous grants and contracts from the following private and public organizations: Aquitaine Company of Canada, Ltd.; Alberta Advanced Education Endowment Fund; Alberta Environmental Research Trust; Alberta Natural Areas Committee (STEP); Natural Sciences and Engineering Research Council of Canada; Recreation, Parks and Wildlife Foundation; Research Management Division, Alberta Department of the Environment; Student Employment Program, Canada Department of Employment and Immigration; Department of the Physical Plant, University of Alberta. Their support enabled us to purchase necessary buildings, capital equipment, and supplies

and services; and to hire competent staff to achieve the objectives of the project in 1981. This support is most gratefully acknowledged.

This study was conducted under the scientific supervision of Dr. Percy Sims and administrative supervision of Mr. Barry Munson, of the Research Management Division, Alberta Department of the Environment, whose help we greatly appreciated.

The manuscript was typed by Mrs. Evelyn Jamha, whose careful attention to detail was invaluable.

1. INTRODUCTION

1.1 BACKGROUND

The SEADYN project (seasonal dynamics) was born of the conviction that a rigorously defined and documented case history of a few, carefully chosen, boreal forest ecosystems would provide the best vehicle for advancing our present, rudimentary knowledge of the basic principles governing the structure and function of boreal ecosystems in general (see Bormann and Likens 1979). In expressing this view, which advocates thorough, intensive study of small samples of ecosystems with transcontinental ranges in the Boreal Taiga Biome of North America, we hasten to acknowledge the important and continuing contributions already made by the geographically extensive, monographic survey approach to the study of boreal ecosystems (see Tansley 1923; La Roi 1967; Mueller-Dombois and Ellenberg 1974). We believe the time has come for us to seek a more balanced perspective on boreal ecosystems by pursuing the intensive, long-term approach.

Previous studies of the structure and function of terrestrial ecosystems in cold regions of the world have amply demonstrated that their primary producer species have a variety of morphological and physiological adaptations which permit rapid initiation of photosynthesis, growth, and reproduction very soon after, indeed sometimes before, snow melt, thus favoring optimal use of energy and other resources during their relatively short, but light-rich, growing seasons. Examples of these adaptations in green plants of the Boreal Taiga Biome include: evergreen photosynthetic organs in all lichens and bryophytes and many needle- and broad-leaf vascular plants; very rapid leaf expansion and maturation in deciduous and herbaceous vascular plants; and high frost resistance in immature and mature plant tissues in both spring and fall, compared with plants of warmer regions.

Notwithstanding this general tendency for more prompt deployment of photosynthetically active tissue, and for shorter spring and autumn seasons in northern regions, it would be erroneous to infer that no significant changes occur in the structure and function of the

green plant community during the growing season. On the contrary, most arctic and boreal ecosystems are demonstrably changing, not static, entities during the summer months, but this dynamic dimensional property has not heretofore been carefully documented at the plant community level in northern North America.

Several types of dynamic variations can be recognized: (1) instantaneous - changes over very short time intervals; e.g., rate of CO_2 fixation in leaf tissue as mg cm^{-2} h^{-1}; (2) diurnal - changes during the course of a 24 h cycle; e.g., the amount of CO_2 fixed per hour on a frequency polygon; (3) intraseasonal - changes taking place within one season of the annual cycle; e.g., changes in the above-ground biomass of a plant population during the summer shown as g m^{-2} at monthly intervals on a frequency polygon; (4) seasonal - changes between seasons of the annual cycle; e.g., population biomass variation over the four seasons; (5) annual - variations between years, including 'fluctuations' or short-term reversible changes as used by Rabotnov (1974); e.g., changes in maximum population biomass at yearly intervals; (6) successional - long-term, directional changes over several to many years; e.g., changes in community complexity between recognized seral stages leading to the climax.

The focus of attention of this project is on dynamic variation types 3 to 6, including intraseasonal, seasonal, annual and successional variations, in the Boreal Forest Biome of western Canada.

Korchagin and Karpov (1974) reported that seasonal variations and annual fluctuations in the structure of climax coniferous forests in the middle subzone of the Eurasian taiga are slight compared with those of successional forests containing alder, aspen or birch in the same subzone, or with those of climax conifer-hardwoods forests of the southern taiga subzone. They regarded pure coniferous forests as "rather stable systems, well adapted to considerable variations, from year to year, of meteorological conditions and regimes of the soil." After stating that annual variations in meteorological conditions and soil moisture do not significantly affect the proportions of different species or stand structure in coniferous taiga forests, they reported that the rhythms of seasonal development do vary with annual

environmental fluctuations; plant growth rates, foliage development, leaf area, canopy coverage, dates and duration of phenological phases, seed production and reproduction are all significantly correlated with, and probably controlled by, meteorological and soil conditions of the same and previous years. Bråkenhielm and Persson (1980) came to similar conclusions in the Swedish Coniferous Forest Project (SWECON).

Korchagin and Karpov (1974) reported that neighboring stands belonging to different taiga forest site types may behave quite differently in terms of their responses to meteorological and soil conditions. They also recognized that the structural dynamics of taiga forests are, in part, the result of consumer activity by large and small herbivore species, but declined to go further, due to the limited amount of reliable, relevant data on this subject in the U.S.S.R.

In Alberta, extensive quantitative summer surveys of a wide array of plant communities in the Boreal Forest and Rocky Mountain Regions have provided abundant, though usually indirect, evidence of significant intraseasonal and annual variations in the parameters sampled. Consequently, detailed comparisons of community attributes estimated on different dates during the four-month field season cannot easily verify or disprove ecological hypotheses; variations in such attributes over the summer may account for much or even all of the observed differences. There is clearly a need, then, for intensive studies of the structural dynamics of major plant community types in Alberta before more rigorous interpretation and use of summer survey data can be attempted.

Long-term, directional, dynamic variation in a plant community, i.e. 'plant succession', has been defined in many ways and much discussed over the years (e.g., Drury and Nisbet 1973), but a revised version of Odum's (1969) word model of 'ecosystem development' is perhaps most helpful in the context of this project:

> "The orderly process of directional change in biotic community composition, structure and function which leads by stages to a relatively stable, self-perpetuating climax ecosystem in which the species structure of the community stabilizes, the exchange of nutrients tends to be cyclical,

> and in which the relative annual rates of energy fixation and loss tend to form a stable ratio."

In boreal peatland ecosystems the energy fixation:loss ratio is almost invariably >1:1 because annual primary production normally exceeds annual community respiration, the net increase consisting of undecomposed organic matter.

Previous investigations of plant communities in the Boreal Taiga of North America have led some workers (e.g., Rowe 1961, Carleton and Maycock 1978) to question the validity of conventional concepts of 'succession' and 'climax' in this biome. It has been suggested, for example, that the 'relay floristics' model of succession (Connell and Slatyer 1977), in which species composition changes progressively over time, does not conform to post-fire changes in boreal ecosystems because virtually all plant species possess fire adaptations enabling them to survive fires, though their abundances are greatly altered. Similarly, the existence of stable, self-perpetuating, climax communities has been questioned in view of the almost universal and frequent occurrence of fire, and the alleged inability of old-growth forests to maintain themselves in the absence of 'rejuvenation' by fire. Other workers in the Boreal Taiga Biome (e.g., Wali and Krajina 1973, Achuff and La Roi 1977), however, have accepted the concepts of 'succession' and 'climax' without major revision.

According to Daubenmire's polyclimax theory (1968), physical sites with the same potential climax community, i.e., 'biologically equivalent sites' *sensu* Cajander (1926), belong to the same 'habitat type'. If two different sites belonging to the same habitat type are subjected to the same type and intensity of disturbance, e.g., severe crown fire, the post-disturbance secondary successions on these sites will usually be very similar in most important respects.

Among the possible mechanisms of plant succession cited by Connell and Slatyer (1977), biologically-induced environmental modification, and competition for resources (e.g., light, nutrients and water for plants) - with intolerant and competitively inferior species succeeded by tolerant and competitively superior species until

the climax is reached - have been the most frequently inferred causes. These authors argue, however, that other kinds of species interactions, especially predator-prey, may also play an important role in controlling the direction, rate and termination of succession, as well as contributing to the maintenance of the climax community.

It is well known that herbivore species, both vertebrate and invertebrate, do not consume all available plant species, or all the parts of one species, with equal relish or benefit. Forage specificity and forage preferences are known for many boreal animals. Thus some successional stages offer larger quantities and/or higher qualities of food to specified herbivores than others. There is every reason to believe, therefore, that differential feeding behavior by herbivore species will significantly influence, both directly by removal, and indirectly by altering competitive balances, the relative abundance of plant species in successional and climax communities. It is of both theoretical and practical interest to determine the relative importance of (1) physical conditions and resources, and (2) consumer effects, on both long-term succession and short-term seasonal and intraseasonal variation in the plant community components of boreal forest ecosystems.

Knapp (1974) stated that the most objective basis for studies of vegetation change over time is the permanent plot, i.e., an area of limited size with precisely marked boundaries. Observations of vegetation attributes are made at specified time intervals in these plots, and the results compared to show trends. These observations become more valuable as the duration of the study increases. Permanent plots have numerous advantages (Mueller-Dombois and Ellenberg 1974, Bråkenhielm and Persson 1980). Instead of taking an entirely new sample (different set of n sampling units) from the plant community on each sampling date, the same sample can be taken from permanent sampling units, thus avoiding errors associated with statistics computed from different samples. This repetitive sampling strategy is only feasible, however, when non-disruptive observations are made. In this project, e.g., we estimate plant shoot cover at

monthly intervals in protected 'reference stands', using the same sets of permanent sampling units.

Previous investigations (e.g., Whittaker and Woodwell 1968, Waring et al. 1978, Roussopoulos and Loomis 1979) have demonstrated the feasibility and advantages of using easily measured plant attributes (e.g., stem diameter, crown width, shoot cover, shoot height, or combinations of these) to estimate important but less easily measured attributes (e.g., shoot biomass, root biomass, leaf area), using dimensional (allometric) regression analysis. However, there are as yet no validated regression equations for most of the plant species native to boreal forest ecosystems in Alberta, so it has not heretofore been possible to estimate the above-ground biomass or leaf area of plant populations except by destructive, direct harvest methods, which are not acceptable in permanent plots where disturbance must be minimized.

Lieth (1970) has provided an appropriate set of plant phenological parameters to be sampled in permanent plots. His 'phenogram' shows the percentage of species in a particular 'phenophase', i.e., distinguishable phase in the plant life cycle (e.g., flowering, fruiting, dormant), during the course of an annual cycle. His 'phenological spectrum' shows the calendar sequence of phenophases for each species in the plot over the year, with species arranged in order of blossom initiation, breaking of dormancy, etc. 'Phenometric observations' entail measurement of quantitative changes within one phenophase, e.g., shoot biomass of a species population during the growing season, estimated by non-harvest methods.

Recent work on plant-insect interactions tends to support the hypothesis that the timing of flowering phenologies in plant communities has evolved under selective pressure imposed by competition among plants for insect pollinators. Hocking (1968) studied pollination biology in the Canadian Arctic and found more evidence of plant competition for pollinators than of insect competition for plant nectar. Mosquin (1971) studied the activities of pollinating insects in relation to the phenological spectrum (Lieth 1970; see above) of the vascular flora in Banff National Park. He found that

the insect-pollinated plant species tended to have divergent peak flowering periods. Heinrich (1976) studied the flowering phenologies of plant species in bogs, woodlands and disturbed sites. He found that wind-pollinated trees and shrubs had strongly overlapping flowering periods in early spring. Insect-pollinated bog plants, however, had relatively narrow and divergent flowering periods spread evenly across the growing season. He concluded that the bog plants share pollinators over time and may be interdependent for continued 'pollinator service'.

Under natural environmental conditions the plant, animal, and microbial species populations of a terrestrial ecosystem exhibit annually repeating patterns of dynamic behavior (e.g., intraseasonal and seasonal variations) that can be measured quantitatively in permanent plots at suitable time intervals. Each of these species has a unique, genetically determined set of tolerance limits and responses to environmental factors. Hence no two species can respond in precisely the same manner to significant environmental change, whether that change is natural or induced by man. The normal range of dynamic behavior of the plant community component of the ecosystem can be determined by monitoring its performance over a period of years embracing as wide a range of meteorological conditions, consumer activities, and other environmental factors, as possible. Variations in dynamic behavior will reflect the intrinsic stability (see section 1.2) of the ecosystem in a temporally fluctuating environment.

How will such a terrestrial ecosystem respond to a new or significantly altered or cumulatively changing environmental factor? Will its dynamic behavior patterns remain the same? If some of its species are more adversely or favorably affected than others, we should be able to qualitatively detect and quantitatively assess the impact of the changed environment of the ecosystem as a whole. Numerous studies of atmospheric pollutants have demonstrated the differential sensitivity of plant species exposed to them. For example, Garsed et al. (1979) showed that conifer seedlings are more sensitive to long-term exposure to low concentrations of sulphur dioxide than are seedlings of angiosperm trees. That the effects of

pollutants on plants may be indirect as well as direct is shown by the work of Freedman and Hutchinson (1980), who demonstrated that the standing crop of forest litter was larger, the rate of litter decomposition slower, the CO_2 flux from the soil weaker, the acid phosphatase activity in the soil reduced, in forests with soils contaminated by heavy metals from a nickel-copper smelter near Sudbury, Ontario. In both examples, the effects of pollutants should be measurable at the plant community level, e.g., as an altered species structure (see section 1.2) at seasonally comparable dates, or as an altered phenological spectrum (ADBC cf. ABCD), because the relative performances of differentially sensitive species are changed by the pollutant.

Comparison of community attributes (see section 1.2) in permanent plots located in plant communities at the same successional stage on the same habitat type along gradients of increasing (1) grazing pressure, or (2) pollution concentration, should provide very good empirical evidence of the impacts of these factors on terrestrial ecosystems. In short, the possibilities of using the whole plant community as a sensitive indicator of wildlife impact or carrying capacity, or as an integrated, ecological monitoring tool, are very promising indeed. It remains for scientists to explore these possibilities and for technologists to develop and perfect the methodologies.

1.2 DEFINITIONS OF SOME PLANT COMMUNITY ATTRIBUTES

The 'complexity' of a plant community can be assessed in many ways, depending on definition and purpose (May 1975). In this project we will describe complexity in terms of physiognomic attributes (e.g., number of growth-forms, strata, consumer guilds), floristic attributes (e.g., number and evolutionary 'spacing' of taxa), and quantitative attributes (e.g., number of taxa in abundance-classes, number of individuals in size- or age-classes), using indices of richness, evenness, diversity, heterogeneity, etc., (Peet 1974, Pielou 1975) (see below).

The 'stability' of a plant community can be assessed in terms of dynamic variations in community attributes around mean values, resistance to stress factors, ability to recover after perturbations, behavioral predictability, etc. (Holling 1973, Orians 1974, Harrison 1979). Successional communities cannot, by definition, exhibit long-term dynamic stability.

The 'species structure' (*SS*) of a plant community (Odum 1975) refers to the frequency distribution of abundance among the species which collectively constitute that community, where abundance is an attribute common to all species (e.g., biomass, shoot cover, leaf area). Species structure may be described by the 'dominance--diversity' curve of Whittaker (1965) or the 'octave' curve of Preston (1948, 1962) (see also La Roi and Ostafichuk 1982).

The 'species richness' (*R*) of a plant community is the number of species present in that community. Owing to the difficulty of finding very rare species, this attribute is usually underestimated (Pielou 1975).

The 'species equitability,' or 'species evenness' of a plant community denotes the degree of its departure from a community in which all species have equal abundance, i.e., a completely equitable assemblage. Simpson's (1949) Dominance Index (*D*) is commonly used to assess evenness:

$D = \Sigma\ (P_i/P_N)^2$, where P_i is the estimated abundance of species i, and P_N is the total abundance of all species in the community (see Pielou 1975).

The 'species diversity' of a plant community indicates the relative probability of getting individuals of the same species in successive random draws; in diverse communities the chances are very small of getting the same species in successive draws. Diversity is a function of both evenness and richness (Pielou 1975). The Shannon--Weaver (1949) Index (*H'*) is commonly used to assess species diversity:

$H' = -\ \Sigma\ (P_i/P_N)\log_e(P_i/P_N)$, with terms defined as for *D* above.

Pielou (1969) has shown that the maximum species diversity a community can attain (H_{max}) is equal to $\log_e R$, and suggested a new evenness index, which we identify as E, which compares the observed diversity H' with the maximum possible for the observed richness R, i.e.:

$$E = H'/H_{max}.$$

The 'dominance hierarchy' of a plant community (La Roi and Ostafichuk 1982) describes the ranking of species, in order of their estimated mean abundances, from the quantitative dominant species at one extreme to the rarest species at the other extreme, and is effectively displayed by identifying the data points on the species structure curve (see section 4.4.3).

1.3 MAJOR HYPOTHESES AND OBJECTIVES OF THE SEADYN PROJECT

The SEADYN project began in the autumn of 1979. Establishment and survey of reference stands in the Hondo - Lesser Slave Lake area took place during the summer of 1980 (see sections 3.1, 3.2, 3.3). 1981 was the first of five successive years of intensive observations intended to provide data suitable for testing the major objectives and achieving the major objectives of the project.

SEADYN is now a multi-disciplinary, ecosystem project with a growing team of participating scientists and sponsoring organizations. The overall strategy is one of phased implementation of complementary studies in a logically arranged (i.e., precursive) sequence which is patterned after those of successful, long-term projects undertaken elsewhere (e.g., the Hubbard Brook Ecosystem Study in northeastern U.S.A. (Bormann et al. 1970, Bormann and Likens 1979), the H.J. Andrews Experimental Forest Project in the Central Cascades of Oregon, U.S.A. (Dyrness et al. 1974, Zobel et al. 1976), and the Swedish Coniferous Forest Project (SWECON) in central Sweden (Persson 1980). Although the first phase is scheduled to last five years, some of the studies initiated during this period will carry over into succeeding years, and the project will continue as long as the value of its findings will justify.

1.3.1 Major Hypotheses

The following list of 19 hypotheses is sufficient to indicate the scope and thrust of the project, but is by no means comprehensive; non-overlapping hypotheses and objectives of other participants are not detailed in this report. No priority is intended by their numerical order, but adjoining hypotheses are usually more interrelated. Numbers in parentheses after each statement are those of relevant major objectives in the next section (1.3.2).

(1) As the environmental conditions and resources for life in the plant community change - intraseasonally, seasonally, annually, and successionally - the names and relative abundances of their member species will inevitably change. (4,5,7,8,12,14).

(2) Each plant species has a unique pattern of responses to dynamic variations in environmental conditions and resources in the plant community. (4,5,6,12,14).

(3) Dynamic variations in plant populations and communities are correlated with and controlled by meteorological and soil conditions of the current and previous years. (4,5,6,7,8,12,13).

(4) The principal triggering mechanism for initiation of the annual phenological spectrum in a boreal plant community is the date of disappearance of the winter snow pack. (6,9,12).

(5) Dates of peak flowering, leaf area, biomass, litter fall, and other population attributes of species are non-randomly distributed across the snow-free season in boreal plant communities. (6,9,12,13).

(6) The species composition, structure, richness, evenness, diversity and dominance attributes of the plant community vary significantly in a predictable manner during the normal annual cycle of seasonal and intraseasonal environmental variation. (4,5,7,8,9).

(7) The total leaf area, shoot biomass and shoot cover of the vascular plant community vary significantly in a predictable manner during the normal annual cycle of seasonal and intraseasonal environmental variation. (1,2,3,7,9).

(8) The total thallus cover of the terrestrial bryophyte and lichen community varies significantly in a predictable manner during the normal annual cycle of seasonal and intraseasonal environmental variation. (5,8,9).

(9) Species-specific regression equations for prediction of shoot biomass and leaf area from shoot cover differ significantly between habitat types, successional stages, and years. (1,2,3).

(10) Consumer species must adjust themselves to the structural dynamics of their food supply, i.e., the changing quality and quantity of food produced by the plant community. (1,6,9,14).

(11) The carrying capacity of a plant community for a consumer community (herbivores + detrivores) varies intraseasonally, seasonally, annually, and successionally. (1,6,9,14).

(12) Dynamic variations in plant populations and communities are correlated with and controlled by dynamic variations in the consumer community of the current and previous years. (1,6,9,10,14).

(13) The species composition, structure, richness, evenness, diversity and dominance attributes of the plant community change significantly during post-fire, secondary succession on a specified habitat type. (7,8,10,11).

(14) The total leaf area, shoot biomass and shoot cover of the vascular plant community change significantly during post-fire, secondary succession on a specified habitat type. (1,2,3,7).

(15) The total thallus cover of the terrestrial bryophyte and lichen community change significantly during post-fire, secondary succession on a specified habitat type. (8,13).

(16) Successional stages on a given habitat type differ in stability (see section 1.2); the climax community is more stable than seral communities. (9,12,14).

(17) The annual rate of successional advance in a plant community changes significantly during post-fire, secondary succession on a specified habitat type. (7,8).

(18) The phenodynamic behavior of plant species and the phenological spectra of plant communities change significantly during post-fire, secondary succession on a specified habitat type. (6).

(19) Tree populations have more stable age- and size--structures and less random dispersion patterns in later than in earlier successional stages on a specified habitat type. (10,11).

1.3.2 Major Objectives

The primary purpose of this project is to monitor and describe the short- and long-term structural dynamics of eight boreal forest ecosystems on three important habitat types in the Southern Boreal Taiga Subzone of north central Alberta. The list of objectives below indicates how we intend to obtain adequate data from in and around eight 'reference stands' (permanent plots) to test the major hypotheses postulated above. This list is not complete; each major objective has its own cluster of more detailed objectives; other SEADYN investigators have separate but complementary studies underway. Not all of the major objectives were initiated in 1981 (see section 1.4) and of course none has as yet been completed; four more years of observations will be made before this phase of the project ends. Numbers in parentheses after objectives are those of the relevant hypotheses they are designed to serve (see section 1.3.1).

(1) Estimate shoot cover; collect, press, measure leaf area and shoot consumption; and determine oven-dry biomass of randomly selected shoots or branch modules of all vascular species found in the eight reference stands throughout the snow-free season for five consecutive years (note: specimens collected from areas surrounding but not in the reference stands). (7,9,10,11,12,14).

(2) Using data from collected vascular plant material, compute regression equations for the prediction of shoot biomass and leaf area from shoot cover and/or other measured i.e., allometric, attributes. (7,9.14).

(3) Validate and improve shoot biomass and leaf area regression equations by paired allometric-direct harvest methods in plots located outside the reference stands. (7,9,14).

(4) Monitor the structural dynamics of the vascular species populations by estimating the live shoot cover, shoot biomass, and leaf area of each species in each of the eight reference stands at monthly intervals during the snow-free season for five consecutive years. (1,2,3,4,6).

(5) Monitor the structural dynamics of the terrestrial bryophyte and lichen species populations by estimating the live thallus cover of each species in each of the eight reference stands at monthly intervals during the snow-free season for five consecutive years. (6,8).

(6) Monitor the phenological behavior of each vascular species and each important terrestrial bryophyte and lichen species population in each of the eight reference stands during the snow-free season for five consecutive years. (2,3,4,5,10,11,12,18).

(7) Monitor the structural dynamics of the vascular plant community, using live shoot cover, shoot biomass, and leaf area data and selected community attributes (section 1.2) in each of the eight reference stands at monthly intervals during the snow-free season for five consecutive years. (1,3,6,7,13,14,17).

(8) Monitor the structural dynamics of the terrestrial bryophyte and lichen community, using live thallus cover and selected community attributes (section 1.2) in each of the eight reference stands at monthly intervals during the snow-free season for five consecutive years. (1,3,6,8,13,15,17).

(9) Synthesize the 'normal' annual cycle of intra-seasonal and seasonal response behavior of the vascular plant and terrestrial bryophyte and lichen communities in the eight reference stands, including the range of departure from 'normal' behavior, based on five years of bio-monitoring data (objectives 4 to 8). (4,5,6,7,8,13,16).

(10) Map the dispersion patterns of tree populations in the eight reference stands by size- and vitality-classes at five-year intervals. (12,13,19).

(11) Assess the population age- and size-structures of the tree populations in the eight reference stands at five-year intervals. (13,19).

(12) Monitor ecologically important meteorological and soil variables in and around the eight reference stands during the five-year period of observation. (1,2,3,4,5,16).

(13) Measure forest litter fall biomass at monthly intervals during the snow-free season in the eight reference stands during the five-year period of observation. (3,5,15).

(14) Monitor the consumption of live, vascular plant shoot biomass by large and small herbivores in the eight reference stands using phenological, shoot biomass, and leaf area observations (objectives 1, 4 and 6). (1,2,10,11,12,16).

1.4 . SEADYN PROJECT STUDIES INITIATED IN 1981

Of the 14 objectives listed above, 10 were started in 1981; nos. 3, 11 and 13 will be initiated in 1982; the 'synthesis' called for in no. 9 will be sequentially developed, starting in 1983 when two years of data are available. The Methods section (3.) describes the experimental design of the project and details the procedures followed in 1981. The Results section (4.) gives a representative sample of the data collected in 1981.

2. STUDY AREA

The study area (Figure 1) lies within the Lesser Slave Lake Lowland east of the Swan Hills Upland in the Athabasca River Basin of north central Alberta (Atlas of Alberta 1969). The topography is generally flat to gently undulating and poorly drained, with large areas of peatland mire complexes. Geological surface deposits in the northern part of the area consist mainly of fine-textured, glacial till and lacustro-till derived from marine shales of Cretaceous age (Scheelar 1975). In the southern part, on both sides of the Athabasca River, coarse-textured, fluvial deposits predominate; these have been re-worked by wind action into aeolian landforms with relatively dry sand dune ridges and wet swales (Scheelar 1975). Hence the three most extensive soil parent materials in the study area are peatland, glacial till, and aeolian sand, in that order.

The climate of the study area is classed as 'southern boreal' according to the Finnish system (Ahti et al. 1968) and as 'continental subarctic' according to the new Thornthwaite system (1948; Sanderson 1948), based upon 30-year normals (Environment Canada 1975) from the nearest major meteorological stations (Slave Lake, 40 km WNW; Athabasca, 80 km SE). Figure 2 is the standard climatic diagram (Walter and Lieth 1967; Walter 1979) for Slave Lake. Mean annual potential evapo-transpiration (Thornthwaite and Mather 1957) is *ca.* 500 mm at both Slave Lake and Athabasca, whereas mean annual total precipitation is 473 mm at Slave Lake and 420 mm at Athabasca. The mean annual number of growing degree-days >0°C (Edey 1977) is 2,194 at Slave Lake and 2,236 at Athabasca.

The vegetation of the study area is typical of the Boreal Mixedwood Section (18a) of Rowe (1972) and Moist Subregion of the Boreal Mixedwood Ecoregion (8) of Strong and Leggat (1981), given the subdued physiography with its preponderance of peatlands. Though located near the northeastern flank of the Swan Hills, a major highland plateau with outliers of Cordilleran flora and vegetation, the study area occurs at a much lower elevation (600 m ASL cf. 1200 m ASL) and shows very little botanical or other evidence of

Figure 1. The SEADYN study area, showing the approximate locations of the eight reference stands. Precise locations are given in Table 2, p 43.

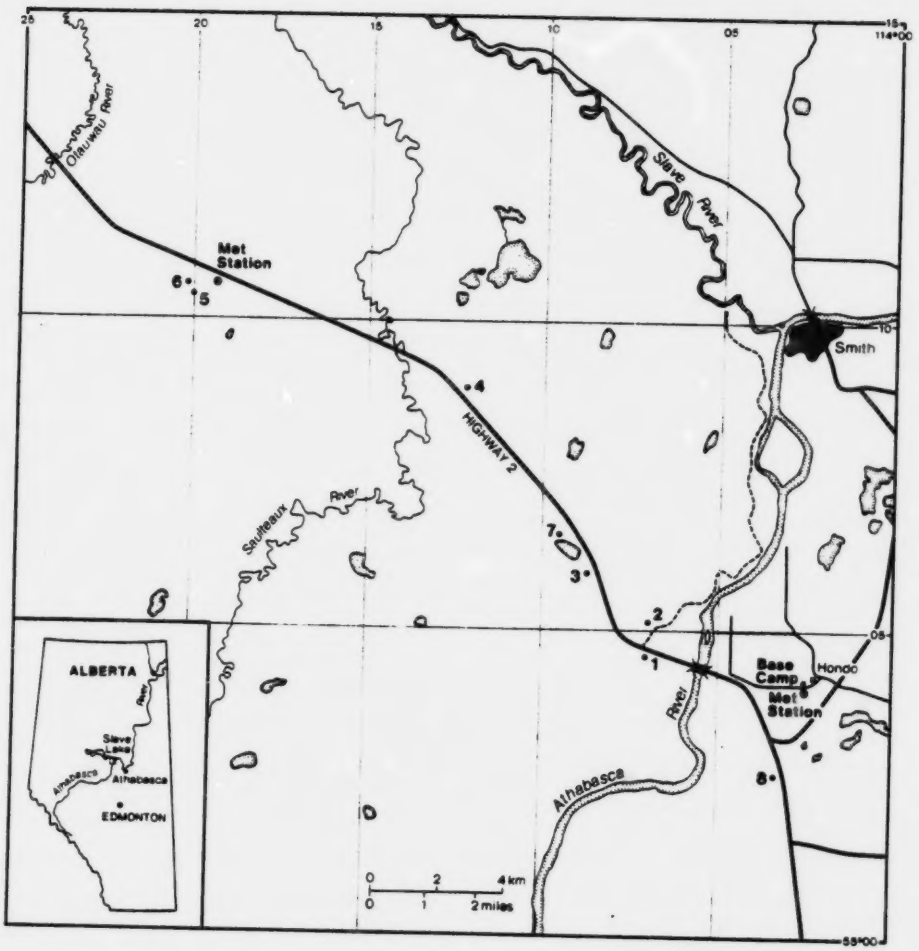

Otauwau River
Met Station
Slave River
Smith
HIGHWAY 2
Steffeaux River
Base Camp & Met Station
Honco
Athabasca River
Athabasca
ALBERTA
Slave Lake
Athabasca
EDMONTON
0 2 4 km
0 1 2 miles
114°00
55°00

Figure 1.

Figure 2. Climatic diagram for the Slave Lake Meteorological Station (55°17' N, 114°38' W, 586 m ASL). Constructed after Walter (1979) using data from Environment Canada (1975).

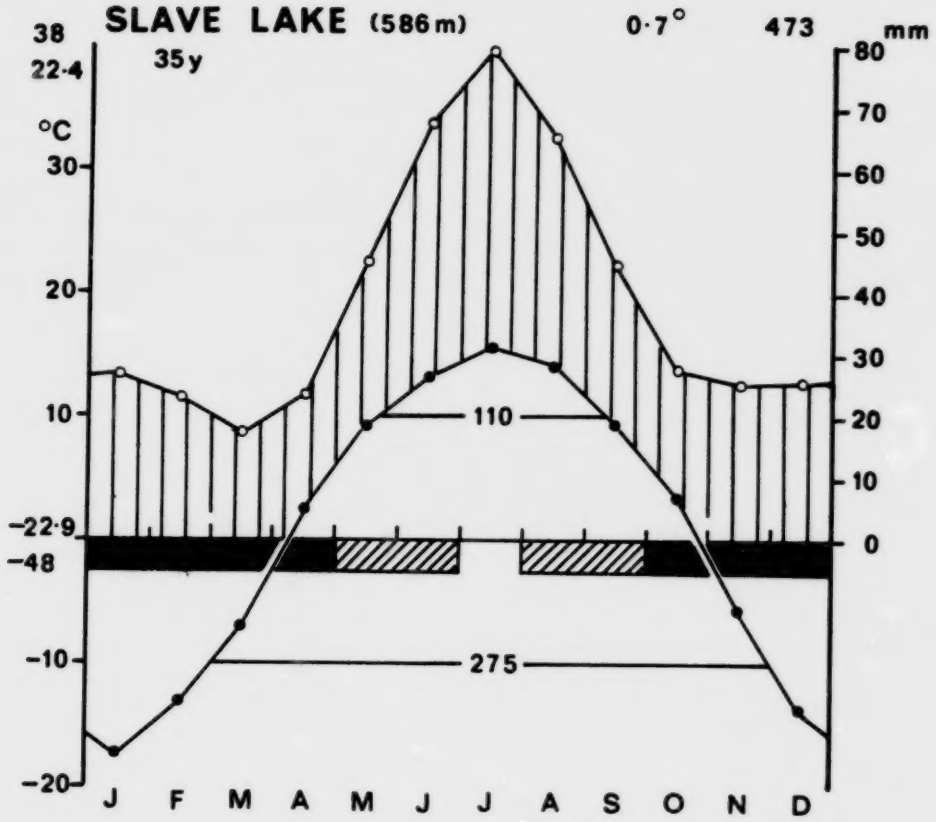

SLAVE LAKE (586 m)
0·7°
473
mm
38
22·4
35y
°C
30
20
10
-22·9
-48
-10
-20
80
70
60
50
40
30
20
10
0
110
275
J F M A M J J A S O N D

Figure 2.

Cordilleran influence. The prevailing vegetation on upland soils derived from glacial till is mixedwood forest dominated in younger stands by *Populus tremuloides* (aspen) and in older stands by *Picea glauca* (white spruce), with lesser amounts of *Abies balsamea* (balsam fir), *Betula papyrifera* (paper birch), and *Populus balsamifera* (balsam poplar). On upland soils derived from aeolian sand *Pinus banksiana* (jack pine) woodland and forest are predominant, with *Picea glauca* invading the older stands, but some sites are dominated by *Populus tremuloides*. Peatland soils support a variety of treed and treeless plant communities; where tree growth is possible *Picea mariana* (black spruce) and *Larix laricina* (American larch) are the usual dominants, the former being more important in older stands.

The most common soil subgroup (Canada Soil Survey Committee 1978) on glacial till deposits is an Orthic Gray Luvisol; on aeolian sands it is an Eluviated Eutric Brunisol; on wooded peatlands it is a Typic Mesisol. Scheelar (1975) has completed a detailed soil survey of Educational Natural Areas in the study area.

Although the fire history of the study area has not been investigated, we have taken enough increment cores and observed enough old burns in the field and on airphotos to make the following, tentative, observations. Virtually every surveyed site, both upland and peatland, contains some evidence of past fire (e.g., charcoal, burn scars on trees) but not necessarily during the life of their oldest living trees. Neighboring 'islands' of upland habitat found in large expanses of peatland can vary dramatically in stand origin date, suggesting that the peatlands sometimes function as natural fire breaks. There seem to have been few, if any, extensive fires in the area since about 1940. Some forests show no evidence of fires since 1815, i.e., they have been unburned for more than 165 years. Hence the age range of forest stands in the study area is at least 40 to 165 years.

3. METHODS

3.1 SELECTION OF REFERENCE STANDS IN 1980

The design of this project required inclusion of 'reference stands' (i.e., permanent plots in which intensive, non-disruptive studies are made) on each of the three most extensive 'habitat types' (*sensu* Daubenmire 1968) in the study area. Based on topographic and edaphic site criteria, these habitat types are:

(1) *Picea glauca* [*Pinus banksiana*] on aeolian sand.

(2) *Picea glauca* [*Populus tremuloides*] on glacial till.

(3) *Picea mariana* [*Larix laricina*] on peatland.

After wildfire, sites on the first habitat type are characteristically dominated by *Pinus banksiana*, while those on the second are dominated by *Populus tremuloides;* the climax co-dominant trees on both habitat types are *Picea glauca* and *Abies balsamea*, the former usually having higher biomass. *Picea mariana* is the climax dominant on wooded peatlands, with *Larix laricina* the dominant or co-dominant seral tree after fire or during primary (i.e., hydrarch) succession in lowlands.

Reconnaissance surveys in the study area in 1980, using forest cover type maps, airphotos and phytosociological and soil observations on the ground, yielded a list of 50 candidate reference stands belonging to the three major habitat types. The reference stands chosen for intensive study are the ones which best met the following acceptance criteria: (1) uniform development in terms of physiognomy, floristics and site properties over an area of at least two hectares; (2) significantly different stage in succession cf. other reference stands for the same habitat type; (3) topographic and edaphic properties which assure correct placement in the designated habitat type; (4) enough indicator plant species present in or nearby to verify that the site is correctly placed in the designated habitat type; (5) reasonable accessibility (less than 10 minutes' walk from highway in snow-free season) with minimal safety hazards to research workers; (6) maximum protection from natural and man-induced disturbances for a prolonged period of time, i.e., preferably located in educational or scientific natural areas protected by law.

3.2 PROCEDURE FOR ESTABLISHMENT OF REFERENCE STANDS IN 1980

One 50 x 50 m (1/4 ha) reference stand was established in the center of each of the eight approved study sites. Using declination-corrected compasses, cloth metric tapes, 121 one-meter lengths of 2.5 cm diameter grey PVC pipe, and a Dymo tape labelling tool, the reference stand was gridded and staked into 100 5 x 5 m square sampling units, each identified on its SW corner post, by inserting stakes at 5 m intervals parallel to and 5 m from the initial 50 m baseline along the South boundary of the reference stand, then repeating this process, always starting from the 50 m baseline along the West boundary, until the grid was complete. Care was taken to minimize disturbance to the plant cover, deadfall and other natural features within the reference stand, but some unavoidable damage did result from the establishment process.

Figure 3 shows the configuration, compass orientation, and sampling unit numbering system employed in all eight references stands. The same dimensions and procedures were used in establishing 16 reference stands in the Athabasca Oil Sands area of northeastern Alberta in 1981. One reference stand can be established by an experienced team of three persons in three to five hours, depending upon the nature and extent of understory vegetation and deadfall, topography, weather, etc.

3.3 PROCEDURE FOR MONTHLY SURVEY OF PLANT COMMUNITIES DURING THE SNOW-FREE SEASON

3.3.1 Vascular Plant Community

At monthly intervals during the snow-free season ocular estimates of the above-ground live shoot cover (i.e., area of vertical projection of leaves, stems, flowers, fruits, etc. expressed as a fraction of plot area) of each vascular plant species population were made to the nearest 1% or '+' for 0.5%, 'R' for 0.1%, '•' for 0.01 %, in each of 25 of the 100 5 x 5 m sampling units in the reference stand, on computer-formatted data sheets. Sampling intensity was therefore 25% for vascular species; sample size was $n = 25$; means and standard

Figure 3. Dimensions and orientation of standard reference stand established in each of the eight boreal forest ecosystems of the SEADYN project. 'V' and 'B' in the 5 x 5 m squares denote the sampling units for monthly surveys of the vascular and terrestrial bryoid (bryophyte + lichen) community components. Locations of bryoid microplots are also indicated, as small squares in lower left corners of 5 x 5 m squares, with 'p' indicating microplots where photos are taken. See details in Methods.

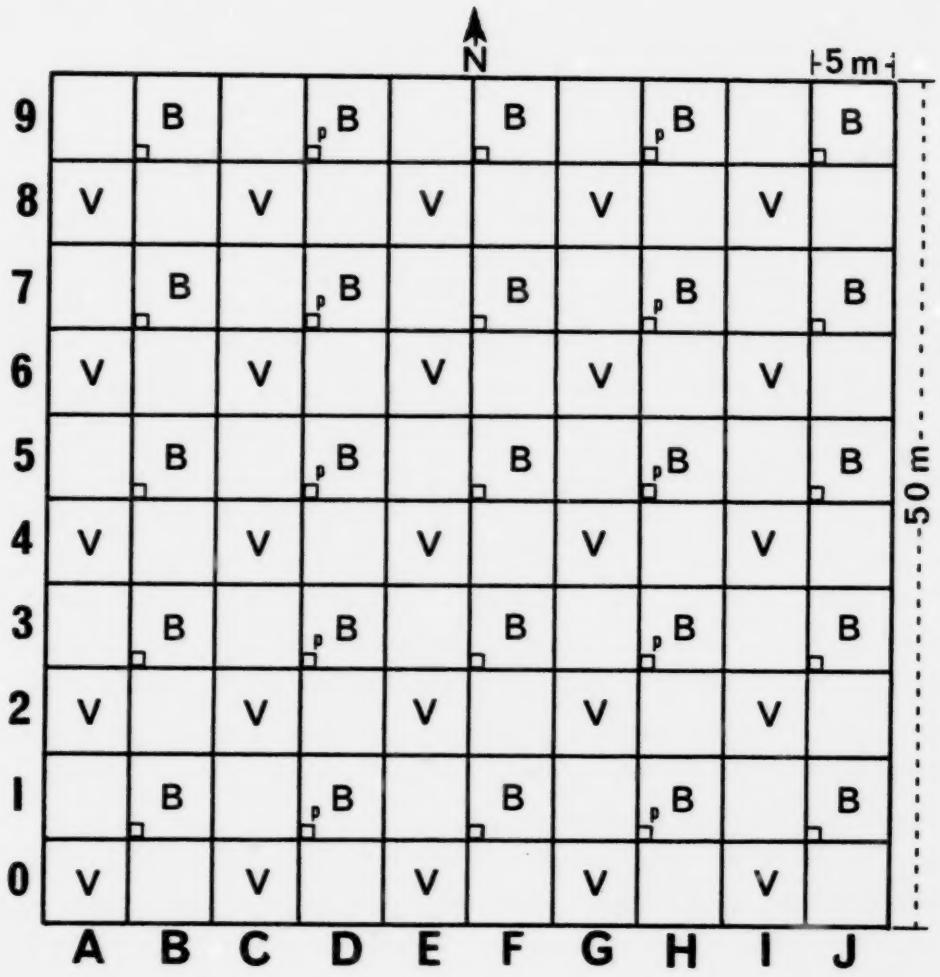

N
5 m
50 m
9 B pB B pB B pB B
8 V V V V V V V
7 B pB B pB B pB B
6 V V V V V V V
5 B pB B pB B pB B
4 V V V V V V V
3 B pB B pB B pB B
2 V V V V V V V
1 B pB B pB B pB B
0 V V V V V V V
A B C D E F G H I J

Figure 3.

deviations of plant cover were computed for each species based on this monthly sample. Placement of the sampling units was the same in all reference stands, i.e., a systematic arrangement of alternate squares (columns A, C, E, G, I) in alternate 'survey rows' (0, 2, 4, 6, 8) such that 'control rows' 1, 3, 5, 7, and 9 were not disturbed by the survey process. Figure 3 gives the locations of the surveyed sampling units ('V' = vascular). Plot frequency was determined for each vascular plant species based on its % occurrence in the 25 sampling units.

Plants do not have to be rooted in the 5 x 5 m sampling units to be included in the cover and plot frequency estimations of the species population to which they belong; hence portions of tree or shrub or herb crowns overhanging the sampling unit were included in the cover estimate for that sampling unit. Attached dead foliage, branches, etc. were not included in the cover estimates even though these can have significant cover in spring and fall.

Vascular plant species are tabulated by major growth-form groups in the individual reference stand tables and synthesis table for each monthly survey (see section 4.4); these groups are tree, shrub, forb, graminoid, and pteridophyte; estimated cover of these growth-forms was computed as the summation of their component species' cover estimates, hence a growth-form can theoretically exceed 100% cover in a luxuriant sward. Similarly, the cover of the total plant community is taken as the summation of its component growth-forms, vascular and bryoid (see next section).

Vascular plant nomenclature now follows Flora of Alberta (Moss 1959) but will follow the revised edition by Packer (1982, in press) in future years. A separate SEADYN herbarium collection has been created and will be maintained in the Plant Ecology Section, Department of Botany, University of Alberta, for the duration of the project, but voucher specimens will be deposited in the University of Alberta Herbarium (ALTA).

3.3.2 Terrestrial Bryophyte and Lichen Community

Bryophyte and lichen species growing on or near the forest floor were surveyed in precisely the same manner as vascular plant species in August of 1980 and in May and June of 1981, permitting comparison of the means and standard deviations of all species, irrespective of growth-form, in the same samples. This survey procedure, however, will henceforth be repeated only at annual intervals in August. The data in section 4.4 are from the June 1981 survey, using 25 5 x 5 m squares.

Starting in June of 1981 and continuing thereafter at monthly intervals during the snow-free season, ocular estimates of the live thallus cover of terrestrial bryophyte and lichen species populations have been made in 25 71 x 71 cm (0.5 sq m) permanent microplots, located adjacent to corner stakes as shown in Figure 3 ('B' = bryoid). This size of sampling unit is much more satisfactory for obtaining accurate monthly estimates of changes in bryophyte and lichen cover since almost all of these small plants can be seen from one vantage point. Sampling intensity in microplots was therefore 0.5% for bryophytes and lichens; sample size was $n = 25$; means and standard deviations of plant cover are computed for each species based on this monthly sample.

In addition to the monthly ocular estimates of bryophyte and lichen cover, 35 mm color photos were taken of 10 microplots from a standard, oblique, tripod position *ca.* 1 m above-ground. These time-lapse photos will be analyzed in the laboratory for changes not noted in the field; they document not only bryophyte and lichen population dynamics and phenolgy, but also those of understory vascular species, the amount and status of litter fall, etc. Samples of these photos appear in the Appendix (section 7.1 and 7.2).

Moss nomenclature follows Crum et al. (1973); liverworts follow Bird and Hong (1975); lichens follow Hale and Culberson (1970) and Brodo and Hawksworth (1977).

3.4 PHENOLOGICAL OBSERVATIONS OF VASCULAR PLANTS

Two strategies of vascular plant phenological observations (see section 1.1) are employed in this project: (1) laboratory measurements on specimens collected from designated harvest areas adjoining the reference stands and preserved at frequent intervals during the snow-free season; (2) field measurements on number-tagged live specimens located in the reference stands at frequent intervals during the snow-free season. Observations of preserved material can be more detailed and precise, and the material is available for re-examination using refined techniques, etc., whenever desired. Field observations of tagged live plants are made on the same individuals, so that phenodynamic variations between plants do not arise, and the case histories of each plant can be documented over an indefinite period of time.

The procedure for collection and preservation of plants on which phenological observations are made in the laboratory is detailed in the next section (3.5); the same plants are used for shoot cover, leaf area and above-ground biomass determinations.

The field observation procedure was as follows: Five randomly chosen specimens of each species recorded in a reference stand were located and number-tagged around the outer perimeter, i.e., just inside the boundary of the reference stand; the position of each identified specimen was mapped to facilitate re-location and re-observation. Species which are very rare in the reference stand frequently have fewer than five tagged individuals because they simply do not occur. Shrubs, trees, and clonal herbaceous plants (e.g., *Aralia nudicaulis*) were tagged such that a designated branch or shoot became the phenological observation module for leaf counts, etc. Herbaceous plants were identified with aluminum tags on stainless steel pins inserted in the ground close to the plant; woody plants were identified with aluminum tags tied to the branch module with brass wire.

A standard set of five phenological observations was made on each tagged specimen in each of the eight reference stands at *ca.* 14-day intervals from mid-May to late August in 1981 as follows:

(1) Vegetative Phenophase (*V*) - i.e., distinguishable phase in the annual vegetative life cycle (Lieth 1970). The vascular flora of the study area is divisible into five vegetative growth-form groups, each of which has a somewhat different set of phenophases (Table 1).

(2) Reproductive Phenophase (*R*) - i.e., distinguishable phase in the annual cycle of sexual reproduction. The vascular flora is divisible into two reproductive groups, i.e., angiosperms with petaliferous or showy sepaliferous flowers (e.g., *Aster ciliolatus, Lonicera involucrata*) and plants with catkins, strobili, cones and sori (e.g., *Populus tremuloides, Lycopodium obscurum, Pinus banksiana, Dryopteris spinulosa),* each with a somewhat different set of phenophases. (Table 1).

(3) Height of Plant (*H*) - i.e., maximum above-ground dimension of plant or plant module (branch) in its normal posture. In plants with readily separable vegetative and reproductive structures of significantly different stature (e.g.,*Pyrola virens* has basal rosette leaves at ground level (0-4 cm) and flowering scapes 5-15 cm above ground), two height measurements are made: reproductive/-vegetative.

(4) Number of Leaves (*L*) - i.e., number of visible, live, green leaves on the plant or plant module, including partially consumed or dying leaves so long as they contain living green parts.

(5) Grazing Impact (*G*) - i.e., the intensity of use by herbivores, including defoliators (leaf-eaters, e.g., Tent Caterpillars) and browsers (twig-eaters, e.g., Snowshoe Hare), expressed in terms of a 4-point scale indicating the percentage loss of tissue: (*N*) nil; (*L*) low, less than 10%; (*M*) medium, from 10 to 50%; (*H*) high, more than 50% loss. Woody species can have two grazing impact observations: grazing on leaves and browsing on woody tissue (*G/B*).

Table 1. Vegetative and reproductive phenological phases[a] for vascular plant species in the Hondo - Lesser Slave Lake area of north central Alberta.

1. Vegetative Shoot Phenophases

A. Herbaceous Forbs and Graminoids (above-ground shoots dead in winter)

0 - plant dormant; no above-ground live; carryover lax/decomposing
1 - shoot or leaves emerging from soil; leaves v small and rolled or folded
2 - all leaves immature, i.e., not fully elongated and hardened
3 - shoot has more immature than mature leaves
4 - shoot has more mature than immature leaves
5 - shoot is mature, i.e., has only fully enlarged and hardened leaves
6 - shoot has more healthy than senescing leaves
7 - shoot has more senescing than healthy leaves
8 - shoot has only a few partially green leaves
9 - shoot dead above-ground but remains erect though leaves shrivelled

B. Evergreen and Wintergreen Forbs and Graminoids

0 - shoot dormant but some of previous years leaves green
1 - very small new leaves visible
2 - shoot has more old green than new green leaves; latter mostly immature
3 - shoot has more mature new green than old green leaves
4 - shoot has ceased vegetative growth and has only hardened mature leaves
5 - leaves from oldest cohort mostly dead or rapidly senescing

C. Needle-leaf Evergreen and Deciduous Shrubs and Trees

0 - buds dormant; evergreen foliage mature
1 - buds swollen but scales cover leaves
2 - needles emerging; green visible; pine shoots in 'candle' stage
3 - needles fully elongated but soft, frost-sensitive and lighter color
4 - needles mature and frost-hardy
5 - oldest leaf cohorts becoming desiccated and falling; larch needles yellowing
6 - oldest leaf cohorts and larch needles falling rapidly
7 - oldest leaf cohorts and larch needles completely shed

D. Broad-leaf Deciduous Shrubs and Trees

0 - buds dormant; old leaves shed and decomposing or a few attached/crisped

continued ...

Table 1. Continued.

1 - buds swollen but scales cover leaves
2 - green leaves visible but v small and often folded or rolled
3 - leaves half elongated; supporting shoot elongating rapidly
4 - leaves fully expanded but soft and frost/drought-sensitive
5 - leaves mature and of normal color and texture; shoot elongation complete
6 - leaves beginning to yellow/desiccate; some have fallen
7 - all leaves yellow/desiccated; many have fallen
8 - most leaves have fallen; a few remain attached and turgid
9 - all leaves fallen; many still turgid on ground

E. Broad-leaf Evergreen Shrubs and Trees

0 - buds dormant; evergreen foliage mature
1 - buds swollen but scales cover leaves
2 - green leaves visible but v small and often folded or rolled
3 - leaves half elongated; supporting shoot elongating rapidly
4 - leaves fully elongated but soft and frost/drought-sensitive
5 - leaves mature and of normal color and texture; shoot elongation complete
6 - oldest leaf cohorts desiccating and falling
7 - oldest leaf cohorts completely shed

2. Reproductive Phenophases

A. Angiosperms with petals or showy sepals or bracts ('flowers')

00 - no new floral buds visible and previous year's plant sterile
0 - no new floral buds visible but previous year's plant fertile
1 - floral buds visible and swelling but closed
2 - some floral buds opening but no mature structures present
3 - some flowers mature (have mature pollen and receptive stigmas)
4 - mature flowers more numerous than immature flowers; some immature fruits may be present
5 - no immature flowers present; mature flowers more numerous than fruits
6 - immature fruits more numerous than flowers; some ripe fruits present
7 - flowers absent; unripe fruits more numerous than ripe fruits
8 - ripe fruits more numerous than unripe fruits
9 - all fruits ripe; some dehiscing, drying, etc.

B. Plants with catkins, strobili, cones or sori

00 - no reproductive structures visible in current or previous year
0 - no reproductive structures visible but previous year's plant fertile

continued ...

Table 1. Concluded.

1 - reproductive structures visible but immature
2 - microsporangia shedding spores, pollen when wind-agitated
3 - staminate catkins or microsporangia desiccating or dehiscing
4 - fruits (cones, pistillate catkins) immature and small
5 - fruits of mature size but unripe
6 - fruits ripe with viable seeds
7 - fruits shedding seeds and/or falling from plant

[a] See also Lieth (1970).

An example of one set of phenological observations on a broad-leaf, deciduous shrub is *Viburnum edule* no. 3 in reference stand no. 6 on 27 August 1981: [5 - 0 - 66 - 22 - M]. This means that the leaves were mature and of normal color and texture and shoot elongation was complete; that the plant did not flower in 1981 but did so in 1980; that it was 66 cm tall; that it had 22 leaves; and the defoliation was moderate (Tent Caterpillar).

These phenological data can be synthesized into several useful chroniclers of the structural dynamics of plant populations and communities (see section 1.1 and the hypotheses and objectives in section 1.3).

3.5 VASCULAR PLANT SHOOT COVER, LEAF AREA AND ABOVE-GROUND BIOMASS MEASUREMENTS

The three most important quantitative attributes of vascular plant populations and communities selected for estimation in this project are (1) live shoot cover - the area of the vertical projection of the shoot, expressed either as m^2 of shoot area per m^2 of ground area (i.e., *SAI*, shoot area index), or as a % of the ground area; (2) live leaf area - the total photosynthetic leaf area (one surface of flat leaves; entire surface of cylindric leaves), expressed either as m^2 of leaf area per m^2 of ground area (i.e., *LAI*, leaf area index), or as a % of the ground area; (3) live shoot biomass - living above-ground parts, expressed as oven-dry (65°C) weight in g per m^2 of ground area.

Live shoot cover was estimated directly in the reference stands (see 3.3.1) whereas leaf area and shoot biomass were estimated indirectly by allometric regression analysis as detailed below.

3.5.1 Forbs, Graminoids and Pteridophytes

Depending on availability, one to several individual plants (e.g., *Solidago decumbens*) or plant modules of clonal species (e.g., compound emergent leaf of *Aralia nudicaulis*) of each species recorded in a reference stand were selected at random from designated

harvest areas adjoining that reference stand at *ca.* 10-day intervals during the snow-free season. An ocular estimate of the shoot cover of each plant or plant module was then made *in situ* by vertical projection onto a grid surface (e.g., graph paper placed beneath the plant) and expressed as sq cm. After measuring height and basal diameter the shoot was harvested and placed in a field press, transferred to a wooden press and oven-dried (65°C) at the Hondo Research Laboratory, then taken to Edmonton, sorted and stored in the SEADYN herbarium.

Leaf area of the shoot in sq cm was measured on dot-grids or graph paper either by (1) summing the measured areas of all individual green leaves, if few in number or widely varying in size, or (2) taking a representative sample of leaves (e.g., alternate, every fourth, etc.), if leaves were numerous or very uniform in size, and calculating the total leaf area as the product of leaf density X mean area per leaf. Graminoid leaf areas were estimated by measuring live blade length and mean blade width and either summing the products or calculating total leaf area using leaf density X mean area per leaf as above. The analogous 'photosynthetic surface area' of leafless *Equisetum* shoots was done similarly, using mean circumference of green stem axes instead of mean leaf blade width in the calculations.

After removal of dead and shrivelled (i.e., dry before harvest) leaves the shoot was oven-dried to constant weight at 65°C and weighed, giving above-ground dry weight of live shoot biomass.

A sample data sheet containing the above information together with a sketch of the pressed plant and specimen notes (*Epilobium angustifolium*, collection no. SD-FLAN 517) appears in the Appendix (section 7.3).

Using the above or below (3.5.2) data on shoot or branch cover (*SC, BC*), leaf area (*LA*) and shoot or branch biomass (*SB,BB*) for a species, linear regression equations ($Y = a + bX$) are calculated, setting leaf area and shoot or branch biomass as the dependent variables (Y) and shoot or branch cover as the independent variable (X) as follows:

(1) $SB = a + bSC$, using data from all dates and reference stands.

(2) $LA = a + bSC$, using all data as in (1).

(3) $SB = a + bSC$, using data from one habitat type.

(4) $LA = a + bSC$, using data as in (3).

(5) $SB = a + bSC$, using data from one month.

(6) $LA = a + bSC$, using data as in (5).

By comparing the square regression coefficients (r^2) of these equations and performing appropriate tests of significance, e.g., on the slopes (b) of the regression lines (co-variance), their adequacy as allometric estimators of shoot or branch biomass or leaf area can be assessed. Non-linear regression equations are used if they give superior fit to the scatter diagrams.

3.5.2 Shrubs and Small Trees

One to several branch samples from large and/or clonal shrubs (e.g., *Alnus crispa*) and small trees or entire individual dwarf shrubs (e.g., *Vaccinium vitis-idaea*) of each species recorded in a reference stand were selected at random from designated harvest areas adjoining the reference stand at *ca.* 10-day intervals during the snow-free season. Subsequent treatment, including regression equations, follows section 3.5.1 (above) except that additional measurements of branch internode diameters and lengths and ring counts of the branch or stem base were made to estimate wood volume and branch or stem age.

A sample data sheet containing the above information together with a sketch of the pressed branch and specimen notes (*Arctostaphylos uva-ursi*, collection no. SD-FLAN 547) appears in the Appendix (section 7.3).

3.5.3 Trees

A variety of branch collection methods (e.g., climb and prune, pruning pole, rifle-prune, telephotograph) were feasibility tested in 1981, but no serious attempt was made to estimate leaf area,

leaf biomass, or total above-ground biomass of the mature tree component from monthly tree cover survey data. By the end of the 1982 field season, stem mapping should be complete for all reference stands (section 3.6). This will permit estimation of leaf area, leaf biomass, and total above-ground biomass from live tree diameters, using allometric, species-specific equations, either from tree mensuration literature and/or from our own observations in the study area.

3.6 POPULATION STRUCTURE OF TREE SPECIES

Trees constitute the dominant plant growth-form in the eight reference stands in terms of biomass, productivity and stature, and are probably dominant in terms of environmental influence (forest microclimate, soil properties, etc.) as well. Therefore they deserve attention beyond that accorded to other vascular plants in this project. Three important and dynamically varying tree population attributes (in addition to shoot cover) are being assessed: size--structure, age-structure, and dispersion. Data on these attributes will enhance the prospects for accurately estimating and monitoring dynamic changes in the leaf area and above-ground biomass of tree populations (see section 3.5.3).

The chief source of tree population data is the 'stem map' (a term regularly used by the U.S. Forest Service for detailed maps of living and dead trees in permanent reference stands located in National Forests of the Pacific Northwest, U.S.A.), i.e., an inventory map of the reference stand showing the distribution of living and dead trees by species and size-class (dbh, i.e., trunk diameter at 1.5 m above ground), with each tree identified by an aluminum number tag loosely nailed to the trunk. A stem map is constructed by number-tagging, measuring dbh, and recording the co-ordinates of all trees >2 cm dbh in each of the 100 5 x 5 m sampling units to the nearest decimeter, then plotting these data on maps using computer methods. Fallen trees are mapped by measuring (1) the co-ordinates of their stumps, (2) where they intersect the boundaries of adjoining sampling units, and (3) their length on the

ground. Fallen, well-rotted, unidentifiable tree logs are not mapped. Reference stands will be re-inventoried and new stem maps constructed at 5-year intervals, but newly-fallen trees, etc. will be recorded as frequently as possible, e.g., during the monthly surveys of plant cover.

3.6.1 Size-Structure

The frequency distribution of living and dead stem density per 2 cm dbh-classes per tree species per reference stand is tallied from the stem map data and plotted as histograms.

3.6.2 Age-Structure

The frequency distribution of living trees by age-class and species in the reference stand will be assessed by taking increment cores from a stratified random sample of trees of different dbh-classes and expressed as a histogram. This work will commence in 1982.

3.6.3 Dispersion

The horizontal distribution pattern of living and dead trees by size-classes and species is shown in the stem maps of the reference stands. The dispersion types (e.g., random, contagious, regular) of species will be determined *via* tests available in the literature (e.g., Greig-Smith (1964); see also hypothesis no. 19 in section 1.3.1).

3.7 ENVIRONMENTAL MEASUREMENTS

Six of the 19 major hypotheses postulated in the Introduction (section 1.3.1) require data on dynamic variations of meteorological and soil conditions in boreal forest ecosystems to be tested; hence major objective no. 12 (section 1.3.2) calls for measurements of ecologically important meteorological and soil variables in and around the eight reference stands during the five-year period of observation.

Relatively stable physical site properties of the reference stands, such as topography, geological parent materials, mineral soil texture and moisture-retention, have been assessed in part from air-photos, topographic and soil maps, and soil survey reports (see Study Area, section 2.). In addition, soil profile descriptions and soil analyses were made from seven, randomly placed 1 x 1 m soil pits excavated into the C horizon in areas adjoining each of the reference stands by Wayne Strong, as part of a complementary study of the below-ground components of boreal ecosystems.

3.7.1 Atmospheric Component

Lambrecht thermo-hygrographs equipped with 30-day charts and housed in standard Stevenson screens 1.5 m above ground have been installed at the Hondo Research Laboratory and at the NW end of the study area (Figure 1) for operation during the snow-free season of each year; the 1981 period of observation was from 8 May to 25 October. Also located at these two recording weather stations are a shielded maximum-minimum thermometer (Taylor Sixes type) and a totalizing rain gauge, each installed 50 cm above ground; the Hondo instruments were read daily, those at the NW station at *ca.* four-day intervals, from mid-May to the end of August.

Solar radiation (direct + diffuse short wave) at Hondo was measured with a Belfort bi-metallic actinograph equipped with 7-day charts and mounted horizontally on top of the Stevenson screen containing the thermo-hygrograph in a very open area. Average wind speed was measured daily with a Belfort, three-cup totalizing anemometer mounted 2.5 m above-ground near the Stevenson screen at Hondo. Wind direction, cloud type, cloud cover (%), and presence of dew/frost were recorded daily each morning at Hondo. All of these measurements were made from mid-May to the end of August in 1981.

Three shielded maximum-minimum thermometers (Taylor sixes type)were installed 50 cm above-ground at the NE and SW corners and center of each reference stand in mid-May of 1981; the two corner instruments were read at *ca.* 4-day intervals and the central instrument at 30-day intervals from mid-May to the end of August, and at

30-day intervals thereafter until early November. One rain gauge was installed 50 cm above-ground in open areas near reference stand nos. 2, 4 and 8 to complement those at the recording stations (Figure 1); they were also checked at *ca.* 4-day intervals.

The 1981 meteorological network described above will be maintained or expanded during the remaining four years of the project.

3.7.2 Soil Component

Coleman soil moisture-temperature sensors (stainless steel--enclosed fiberglass resistance block + thermistor) were inserted at mid-horizon positions in the soil profiles (usually three sensors per profile) near the maximum-minimum thermometers inside the NE and SW corners of each reference stand in late May of 1981. Soil moisture and temperature readings were made on an air temperature-compensated Coleman resistance meter at *ca.* 4-day intervals from early June to the end of August, and at 30-day intervals thereafter until early November, 1981.

Additional soil moisture-temperature sensors may be installed in 1982.

3.8 PHOTOGRAPHIC DOCUMENTATION

Good photographs are extremely useful devices for documenting (1) the changing physiognomy of the community, (2) the color, shape and texture of growing, maturing, reproducing and senescing plants, (3) the impact of herbivores, storms, frosts, etc., and (4) the changing conditions of substrates, e.g., litter fall and fallen logs.

Lateral, oblique and vertical-up 35 mm color photos were taken of plants and habitats in each of the eight reference stands in conjunction with the monthly surveys of vascular plant communities (see section 3.3.1) during the snow-free season in 1981. These photos were taken on an opportunistic basis, rather than from fixed positions, in an attempt to capture special phenological events and other changing attributes of the stands where and when they were found.

Oblique, close-up, 35 mm color photos of 10 permanent 71 x 71 cm (0.5 sq m) microplots were taken from fixed tripod positions during the monthly surveys of terrestrial bryophyte and lichen communities (see section 3.3.2) starting in June and ending in early November 1981. The time-lapse microplot photos will permit detailed comparisons of brophyte and lichen growth and reproduction that would otherwise be infeasible.

3.9 DATA COLLECTION, STORAGE, RETRIEVAL AND USE

SEADYN is a multi-disciplinary, team project in which all data are freely and equally available to and shared by participating scientists. Since the project is supported by several private and public organizations (see Acknowledgements), its findings must be regarded as part of the public domain. Hence our policy is to supply specific data to potential users outside the project within one year of the date they are put on file for use by project participants. The first condition to such external use of project data is that full credit be accorded to SEADYN and its specific participants as the data sources in publications, reports, theses, etc. which do, in fact, use the data. The second and last condition is a disclaimer, i.e., neither SEADYN nor its participants will accept liability for errors in the data, difficulties arising from use of the data, etc.

One of the unstated objectives of this report, which is a public document, is to acquaint potential participants and data-users with the types and amounts of data currently being generated, as well as to provide samples of such data for close scrutiny and constructive criticism.

Wherever possible, data are collected in a format that is readily stored in a computer file at the University of Alberta Computing Center. Responsibility for planning and executing a workable scheme for storage and retrieval of SEADYN data in 1981 was assumed by Bill Lee, who created the computer file system now in operation and prepared a written documentation to facilitate continuing use (Lee 1982).

The general procedure followed during the 1981 field season was to tally numeric data on data sheets designed to permit immediate keypunching onto cards or direct input from remote computer terminals at Edmonton and Hondo. Although these data sheets are not always as efficient to use in the field as field staff might prefer, they are undeniably cost-effective in terms of both money and time.

The original raw data sheets or photocopies of same are stored in the SEADYN file of the Plant Ecology Section, Department of Botany, Biological Sciences Building, University of Alberta, Edmonton, and may be examined and duplicated by appointment with the authors. For reasons of safety, use, etc., copies of these data are also stored in the files of participating scientists.

Collections of plants, soils, photos and other non-numeric information are deposited in the Plant Ecology Section; they too may be examined and used by appointment with the authors.

Publications, reports, and theses arising from SEADYN research will be identified by 'Contribution Nos.', as is customary in continuing team projects of this kind; this report is Contribution No. 1.

4. RESULTS

4.1 LOCATIONS OF REFERENCE STANDS AND BASE CAMP

Eight reference stands were chosen, including nos. 1, 2, 3, and 4 on the *Picea glauca* [*Pinus banksiana*] habitat type; nos. 5 and 6 on the *Picea glauca* [*Populus tremuloides*] habitat type; and nos. 7 and 8 on the *Picea mariana* [*Larix laricina*] habitat type (see section 3.1).

All eight reference stands are located within reasonable walking distance of Alberta Highway No. 2 between its junction with Highway No. 44 (east of the Athabasca River bridge) and Otauwau River bridge (Figure 1, p 17). Precise locations are given in Table 2. Each stand is situated within a larger area of the same habitat type, which is in turn located within a larger land parcel protected by a Public Lands Division Reservation for a period of 10 years (1981 to 1991); stand nos. 3, 5, 6, and 8 are situated within permanently protected Educational Natural Areas administered by the Alberta Natural Areas Committee.

The base camp for this project is the Hondo Research Laboratory, Department of Botany, University of Alberta, located in the hamlet of Hondo (Figure 1).

4.2 AGES OF REFERENCE STANDS

Table 3 gives the estimated ages and stand origin dates of the reference stands, based on ring counts of 30 increment cores per stand and wedges sawn from fire-scarred trees, where present. Stand age ranged from 42 to 166 years on aeolian sands, 77 to 125 years on glacial till, and from 55 to 122 years on peatlands.

More detailed analyses of tree population age structure are planned for 1982, so the data in Table 3 are subject to revision when more intensive observations are made. Because few or no extensive fires have occurred in the reasonably accessible portion of the study area since 1940 (see Study Area, section 2.), there are no very young reference stands (i.e., 1 to 40 years) in the project at present.

Table 2. Locations of the eight SEADYN reference stands in the Hondo - Lesser Slave Lake area of north central Alberta. Airphoto coordinates originate from SW corner of the photo image.

Reference Stand Number[a]	Habitat Type	Geographic Coordinates		Legal Position	Airphoto Coordinates		
		Latitude (N)	Longitude (W)	Sect-Twnp-Range (W of 5th Mer)	Photo No.	X (mm)	Y (mm)
1	PIGL[PIBA][b]	55°4'30"	114°7'	20-70-1	AS-1630-161 77-37IR Line 93B	186	34
2	PIGL[PIBA]	55°5'10"	114°7'	29-70-1	AS-1630-161 77-37IR Line 93B	170	90
3	PIGL[PIBA]	55°6'	114°8'45"	31-70-1	AS-1630-260 77-37IR Line 94B	185	21
4	PIGL[PIBA]	55°8'55"	114°12'10"	14-71-2	AS-1631-62 77-37IR Line 95B	185	182
5	PIGL[POTR]	55°10'20"	114°20'	26-71-3	AS-1631-245 77-37IR Line 97B	39	115
6	PIGL[POTR]	55°10'35"	114°20'20"	26-71-3	AS-1631-245 77-37IR Line 97B	28	125
7	PIMA[LALA]	55°2'40"	114°3'20"	10-70-1	AS-1629-263 77-37IR Line 91B	188	99
8	PIMA[LALA]	55°6'35"	114°9'30"	36-70-2	AS-1630-261 77-37IR Line 94B	32	110

[a] Stands are numbered in order of increasing age within habitat types (see Table 3).

[b] See section 3.1 for definitions of habitat types; four-letter code names of tree species detailed in Table 5.

Table 3. Estimated ages and origin dates of the eight SEADYN reference stands located in the Hondo - Lesser Slave Lake area of north central Alberta. Based on a sample of 30 increment cores per stand taken 35 cm above ground and wedges sawn from fire-scarred trees, where present.

Reference Stand Number	Stand Age[a] in 1981 (yrs)	Stand Origin Date
1	42	1939
2	53	1928
3	85	1896
4	166	1815
5	77	1905
6	125	1856
7	55	1926
8	122	1859

[a] Stand age is determined from the oldest trees of the dominant age-class (cohort).

4.3 SOILS OF REFERENCE STANDS

Table 4 gives preliminary classification and analytic properties of the soils in the eight reference stands, based on seven pits excavated near each stand (see section 3.7.2). The dominant soil subgroup (Canada Soil Survey Committee 1978) on aeolian sand is an Eluviated Eutric Brunisol; on glacial till it is an Orthic Gray Luvisol; on organic material it is a Typic Mesisol.

Soil profile development in the four stands belonging to the *Picea glauca* [*Pinus banksiana*] habitat type increases with stand age (cf. Tables 3 and 4), but we cannot now state that this logical correlation is significant in terms of cause-effect.

Reference stand nos. 5 and 6 have a thin layer of coarse outwash material over glacial till, but both stands are nonetheless typical examples of the *Picea glauca* [*Populus tremuloides*] habitat type for the study area.

Although the organic (peat) horizon in stand no. 8 is not thick enough to classify the soil as a Typic Mesisol, it appears thick enough to qualify the site as a peatland ecosystem belonging to the *Picea mariana* [*Larix laricina*] habitat type.

Future SEADYN reports and publications will provide detailed analyses of the physical and chemical properties of the soils.

4.4 MONTHLY SURVEY OF PLANT COMMUNITIES DURING THE SNOW-FREE SEASON

The first monthly survey of the plant communities (see section 3.3) in the eight reference stands was completed in 1980, at the time of their establishment in early August. During 1981 six monthly surveys were made, starting on 11 May and ending on 5 November. In this section we provide complete survey data from August 1981 for vascular plant communities and from June 1981 for the terrestrial bryophyte and lichen communities; data from the other five surveys in 1981 and one survey in 1980 are stored in the SEADYN file and available from the authors.

Table 4. Preliminary soil classification and analytic properties of soils and sites in the eight SEADYN reference stands of the Hondo - Lesser Slave Lake area of north central Alberta.

Reference Stand Number	Dominant Soil[b] Subgroup	Representative Texture[b] of C horizon	Parent Material/Landform	Percent Slope	Drainage[c]
1	Orthic Eutric Brunisol	Sand	Aeolian - Sand dune	2 - 5	Well to rapid
2	Eluviated Eutric Brunisol	Sand	Aeolian - Sand dune	2 - 5	Well to rapid
3	Eluviated Eutric Brunisol	Sand	Aeolian - Sand dune	2 - 5	Well to rapid
4	Orthic Gray Luvisol(?)	Sand	Aeolian - Sand dune	2 - 5	Well to rapid
5	Orthic Gray Luvisol	Sandy Clay Loam	Thin outwash/moraine	2 - 5	Moderately well
6	Orthic Gray Luvisol	Sandy Clay Loam	Thin outwash/moraine	2 - 5	Moderately well
7	Typic Mesisol	Organic	Deep organic deposits over aeolian materials	0 - 2	Very poorly
8	Terric Humisol and Rego Gleysol complex	Organic (*ca.* 50 cm) over sandy loam	Shallow organic deposits over aeolian materials	0 - 2	Poorly

[a] Classification and analysis by Wayne Strong, Department of Botany, University of Alberta.

[b] Based on Canada Soil Survey Committee (1978).

[c] Based on Canada Department of Agriculture (1974).

We chose to use August 1981 vascular data in this report to facilitate comparison of the four reference stands on aeolian sand parent materials in the study area with 14 ecologically analogous reference stands established and surveyed by the same procedures in the Athabasca Oil Sands area of northeastern Alberta, also in August of 1981 (La Roi and Ostafichuk 1982). It should be noted that June was the last 1981 survey of terrestrial bryophyte and lichen communities using the large 5 x 5 m sampling units (see section 3.3.2) also used in the Oil Sands survey.

4.4.1 Quantitative Data for Individual Reference Stands

Table 5 gives the results of the August 1981 survey of the vascular plant communities and June 1981 survey of terrestrial bryophyte and lichen communities in the eight reference stands. The statistics contained in this table were generated by the SEADYN-SPSS computer procedure of Lee (1982; see sample printout in Appendix, section 7.3) and include: (1) species richness (R) and % cover of vascular plants, terrestrial bryophytes, terrestrial lichens, and the total plant community (exclusive of the epiphytic lichen component, which has not been surveyed thus far in the project); (2) plot frequency of each species (% occurrence in 5 x 5 m sampling units); (3) mean % cover and standard deviation of mean cover of each species. In each reference stand table, species are arranged in order of decreasing estimated mean % cover within the eight major plant growth-form groups; thus the 'dominance hierarchies' (see section 1.2) within the growth-forms are readily compared among reference stands.

Using the data in these tables, tests of significance can be performed on the various community and population attributes. In all cases the sample consists of 25 sampling units ($n = 25$) out of a possible total (frame) of 100 5 x 5 m sampling units in each 50 x 50 m reference stand, i.e., sampling intensity is 0.25. Since there is no evidence of regular dispersion in any of the surveyed plant populations, the samples may be treated as a set of randomly placed

[Text continued on page 73]

Table 5. Quantitative plant community data for the eight SEADYN reference stands located in the Hondo - Lesser Slave Lake area of north central Alberta. Each reference stand is treated as a three-page data-set. For details of survey methods see section 3.3, p 23; for details on statistical aspects see section 4.4.1. Species are listed in order of decreasing mean cover % within the growth-form to which they belong. There are two rankings: vascular and bryoid (e.g., *Arctostaphylos uva-ursi* has the highest mean % cover in reference stand no. 1, and therefore is ranked as the no. 1 vascular species; *Cladina mitis* is the no. 1 bryoid, etc.).

SEADYN PROJECT — HONDO - LESSER SLAVE LAKE AREA

Reference Stand No. 1 Survey Date: Vas. 1981-8-17, Bry. 1981-6-10

Habitat Type: *Picea glauca* [*Pinus banksiana*] on aeolian sand

Sociation Name: PIBA/ARUV/CLA MIT

Vascular Plants	Species Richness = 41	Cover = 40.31%
Bryophytes	Species Richness = 8	Cover = 5.02%
Terrestrial Lichens	Species Richness = 23	Cover = 47.88%
Plant Community	Species Richness = 72	Cover = 93.21%

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
Trees					
PIBA	*Pinus banksiana*	100	9.34	8.40	2
POTR	*Populus tremuloides*	4	0.040	0.200	23
PIGL	*Picea glauca*	4	0.020	0.100	31
	Total Tree Cover = 9.40%				
Shrubs					
ARUV	*Arctostaphylos uva-ursi*	100	18.04	8.41	1
VAVI	*Vaccinium vitis-idaea*	100	6.20	5.72	3
ALCR	*Alnus crispa*	16	0.820	3.07	4
VAMY	*Vaccinium myrtilloides*	88	0.720	0.874	6
ROAC	*Rosa acicularis*	80	0.517	0.581	7
AMAL	*Amelanchier alnifolia*	84	0.476	0.361	10
PRPE	*Prunus pensylvanica*	40	0.136	0.256	15
RUST	*Rubus strigosus*	12	0.104	0.408	18
SHCA	*Shepherdia canadensis*	20	0.081	0.236	20
SABE	*Salix bebbiana*	4	0.004	0.020	37
	Total Shrub Cover = 27.10%				
Forbs					
LIBO	*Linnaea borealis*	52	0.796	1.41	5
ASLA	*Aster laevis*	100	0.484	0.319	9
MACA	*Maianthemum canadense*	100	0.453	0.443	11
GABO	*Galium boreale*	96	0.181	0.186	14
SODE	*Solidago decumbens*	88	0.130	0.170	16
GELI	*Geocaulon lividum*	8	0.100	0.408	19
ANMU	*Anemone multifida*	84	0.059	0.048	22
VIAD	*Viola adunca*	52	0.034	0.046	25
HICA	*Hieracium canadense*	48	0.034	0.047	26
PYVI	*Pyrola virens*	28	0.033	0.103	27

continued...

Reference Stand No. 1 Continued

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
FRVI	*Fragaria virginiana*	16	0.028	0.102	28
ERGL	*Erigeron glabellus*	36	0.025	0.043	29
PYSE	*Pyrola secunda*	8	0.024	0.101	30
ANPA	*Anemone patens*	40	0.018	0.037	32
CARO	*Campanula rotundifolia*	76	0.015	0.026	33
ARCA	*Artemisia campestris*	16	0.009	0.028	35
ANRA	*Antennaria racemosa*	8	0.008	0.028	36
EPAN	*Epilobium angustifolium*	8	0.0008	0.003	38
LIPH	*Lilium philadelphicum*	8	0.0008	0.003	39
ACMI	*Achillea millefolium*	4	0.0004	0.002	40
	Total Forb Cover = 2.43%				
	Graminoids				
CXUM	*Carex umbellata*	96	0.496	0.465	8
ORPU	*Oryzopsis pungens*	100	0.304	0.313	13
ELIN	*Elymus innovatus*	80	0.122	0.174	17
ORAS	*Oryzopsis asperifolia*	48	0.078	0.218	21
ELGL	*Elymus glaucus*	36	0.014	0.033	34
CXFO	*Carex foenea*	4	0.0004	0.002	41
	Total Graminoid Cover = 1.01%				
	Pteridophytes				
LYTR	*Lycopodium tristachyum*	16	0.320	0.900	12
EQVA	*Equisetum variegatum*	96	0.038	0.043	24
	Total Pteridophyte Cover = 0.36%				
	Bryophytes				
PLE SCH	*Pleurozium schreberi*	56	3.09	7.42	2
HYL SPL	*Hylocomium splendens*	32	1.25	3.54	3
POL PIL	*Polytrichum piliferum*	68	0.520	0.850	6
POL JUN	*Polytrichum juniperinum*	64	0.064	0.049	15
PTI C-C	*Ptilium crista-castrensis*	28	0.057	0.200	16
DIC POL	*Dicranum polysetum*	40	0.036	0.049	21
ORT FLA	*Orthodicranum flagellare*	8	0.004	0.020	27
PTI CIL	*Ptilidium ciliare*	4	0.0004	0.002	31
	Total Bryophyte Cover = 5.02%				

continued...

Reference Stand No. 1 Concluded

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
Terrestrial Lichens					
CLA MIT	*Cladina mitis*	100	44.4	25.96	1
PEL MAL	*Peltigera malacea*	80	1.14	1.14	4
CLA PHY	*Cladonia phyllophora*	84	0.564	0.682	5
CLA MUL	*Cladonia multiformis*	92	0.416	0.448	7
CLA COC	*Cladonia coccifera*	92	0.348	0.506	8
PEL APH	*Peltigera aphthosa*	32	0.180	0.467	9
CLA CHL	*Cladonia chlorophaea*	72	0.180	0.312	10
PEL PUL	*Peltigera pulverulenta*	12	0.128	0.439	11
CET PIN	*Cetraria pinastri*	96	0.096	0.020	12
STE ALP	*Stereocaulon alpinum*	8	0.080	0.277	13
CLA PYX	*Cladonia pyxidata*	32	0.068	0.199	14
CLA GRA	*Cladonia gracilis*	52	0.048	0.051	17
CLA UNC	*Cladonia uncialis*	12	0.048	0.200	18
CLA GON	*Cladonia gonecha*	48	0.044	0.050	19
CLA COR	*Cladonia cornuta*	40	0.040	0.050	20
CLA CON	*Cladonia coniocraea*	36	0.032	0.047	22
CET ERI	*Cetraria ericetorum*	28	0.028	0.046	23
CLA STE	*Cladina stellaris*	16	0.012	0.033	24
CET NIV	*Cetraria nivalis*	12	0.0084	0.028	25
CLA CRT	*Cladonia cristatella*	16	0.0052	0.020	26
CLA CAP	*Cladonia capitata*	4	0.0040	0.020	28
PEL RUF	*Peltigera rufescens*	16	0.0016	0.004	29
CLA CEN	*Cladonia cenotea*	4	0.0004	0.002	30

Total Terrestrial Lichen Cover = 47.88%

SEADYN PROJECT — HONDO - LESSER SLAVE LAKE AREA

Reference Stand No. 2 Survey Date: Vas. 1981-8-18, Bry. 1981-6-9

Habitat Type: *Picea glauca* [*Pinus banksiana*] on aeolian sand

Sociation Name: PIBA/ALCR/ROAC/ARUV/CLA MIT

Vascular Plants	Species Richness = 40	Cover = 48.71%
Bryophytes	Species Richness = 8	Cover = 6.46%
Terrestrial Lichens	Species Richness = 19	Cover = 38.55%
Plant Community	Species Richness = 67	Cover = 93.72%

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
Trees					
PIBA	*Pinus banksiana*	96	12.92	9.78	2
PIGL	*Picea glauca*	4	0.040	0.200	29
POTR	*Populus tremuloides*	4	0.0040	0.020	39
	Total Tree Cover = 12.96%				
Shrubs					
ARUV	*Arctostaphylos uva-ursi*	100	13.45	14.26	1
VAVI	*Vaccinium vitis-idaea*	100	7.57	7.11	3
ALCR	*Alnus crispa*	76	5.58	5.75	4
ROAC	*Rosa acicularis*	100	1.90	0.791	5
VAMY	*Vaccinium myrtilloides*	80	1.10	1.35	6
SHCA	*Shepherdia canadensis*	32	0.740	2.98	8
AMAL	*Amelanchier alnifolia*	88	0.473	0.520	11
PRPE	*Prunus pensylvanica*	28	0.164	0.312	16
RUST	*Rubus strigosus*	20	0.104	0.249	20
PRVI	*Prunus virginiana*	20	0.084	0.186	24
ROWO	*Rosa woodsii*	4	0.080	0.400	25
SABE	*Salix bebbiana*	4	0.020	0.100	32
	Total Shrub Cover = 31.27%				
Forbs					
MACA	*Maianthemum canadense*	96	0.928	0.908	7
ASLA	*Aster laevis*	88	0.672	0.645	9
ARNU	*Aralia nudicaulis*	24	0.624	1.49	10
LIBO	*Linnaea borealis*	56	0.437	0.737	12
GELI	*Geocaulon lividum*	44	0.396	0.887	13
SODE	*Solidago decumbens*	80	0.233	0.268	14
ERGL	*Erigeron glabellus*	72	0.145	0.187	17

continued...

Reference Stand No. 2 Continued

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
GABO	*Galium boreale*	84	0.141	0.165	18
MELI	*Melampyrum lineare*	32	0.096	0.233	22
ANMU	*Anemone multifida*	80	0.090	0.132	23
PYSE	*Pyrola secunda*	24	0.072	0.219	26
ANPA	*Anemone patens*	44	0.049	0.104	27
VIAD	*Viola adunca*	64	0.042	0.048	28
PYVI	*Pyrola virens*	48	0.023	0.040	30
HICA	*Hieracium canadense*	24	0.017	0.037	33
CARO	*Campanula rotundifolia*	84	0.012	0.019	34
	Total Forb Cover = 3.98%				
Graminoids					
ORPU	*Oryzopsis pungens*	88	0.211	0.303	15
ELIN	*Elymus innovatus*	92	0.131	0.170	19
CXUM	*Carex umbellata*	44	0.102	0.272	21
ELGL	*Elymus glaucus*	8	0.020	0.100	31
ORAS	*Oryzopsis asperifolia*	16	0.0088	0.028	35
CXFO	*Carex foenea*	20	0.0020	0.004	40
	Total Graminoid Cover = 0.47%				
Pteridophytes					
EQVA	*Equisetum variegatum*	52	0.0084	0.020	36
LYTR	*Lycopodium tristachyum*	8	0.0080	0.028	37
EQAR	*Equisetum arvense*	8	0.0044	0.020	38
	Total Pteridophyte Cover = 0.02%				
Bryophytes					
PLE SCH	*Pleurozium schreberi*	72	5.70	13.3	2
PTI C-C	*Ptilium crista-castrensis*	40	0.264	0.656	4
HYL SPL	*Hylocomium splendens*	36	0.184	0.466	5
POL JUN	*Polytrichum juniperinum*	72	0.104	0.192	6
POL PIL	*Polytrichum piliferum*	24	0.096	0.275	9
DIC POL	*Dicranum polysetum*	56	0.092	0.196	11
PTI CIL	*Ptilidium ciliare*	12	0.012	0.033	22
CER PUR	*Ceratodon purpureus*	4	0.0040	0.020	26
	Total Bryophyte Cover = 6.46%				

continued ...

Reference Stand No. 2 Concluded

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
Terrestrial Lichens					
CLA MIT	*Cladina mitis*	100	35.7	25.6	1
PEL MAL	*Peltigera malacea*	88	2.01	2.52	3
CLA MUL	*Cladonia multiformis*	68	0.104	0.193	7
PEL APH	*Peltigera aphthosa*	32	0.100	0.274	8
CLA PHY	*Cladonia phyllophora*	60	0.096	0.195	10
CLA STE	*Cladina stellaris*	40	0.072	0.199	12
CLA COC	*Cladonia coccifera*	36	0.072	0.199	13
CET PIN	*Cetraria pinastri*	72	0.072	0.046	14
CLA UNC	*Cladonia uncialis*	28	0.064	0.200	15
CLA COR	*Cladonia cornuta*	28	0.064	0.200	16
CLA CHL	*Cladonia chlorophaea*	48	0.048	0.051	17
PEL PUL	*Peltigera pulverulenta*	8	0.044	0.200	18
CLA GRA	*Cladonia gracilis*	28	0.028	0.046	19
CET ERI	*Cetraria erecetorum*	16	0.016	0.037	20
CLA CRP	*Cladonia crispata*	16	0.012	0.033	21
CLA CON	*Cladonia coniocraea*	16	0.0088	0.028	23
PEL RUF	*Peltigera rufescens*	8	0.0080	0.028	24
CLA PYX	*Cladonia pyxidata*	8	0.0080	0.028	25
CET NIV	*Cetraria nivalis*	4	0.0004	0.002	27

Total Terrestrial Lichen Cover = 38.55%

SEADYN PROJECT — HONDO - LESSER SLAVE LAKE AREA

Reference Stand No. 3 Survey Date: Vas. 1981-8-16, Bry. 1981-6-9

Habitat Type: *Picea glauca* [*Pinus banksiana*] on aeolian sand

Sociation Name: PIBA/PIGL/ALCR/ROAC/ARNU/LIBO/PLE SCH

Vascular Plants	Species Richness = 44	Cover = 52.10%
Bryophytes	Species Richness = 10	Cover = 63.69%
Terrestrial Lichens	Species Richness = 12	Cover = 0.38%
Plant Community	Species Richness = 66	Cover = 116.15%

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
Trees					
PIBA	*Pinus banksiana*	100	26.72	9.09	1
PIGL	*Picea glauca*	72	1.74	2.26	5
POTR	*Populus tremuloides*	24	0.420	1.31	12
PIMA	*Picea mariana*	7	0.245	0.817	18
BEPA	*Betula papyrifera*	28	0.124	0.260	22
ABBA	*Abies balsamea*	4	0.040	0.200	27
	Total Tree Cover = 29.29%				
Shrubs					
ALCR	*Alnus crispa*	100	7.60	4.12	2
ROAC	*Rosa acicularis*	100	1.40	0.750	6
VAMY	*Vaccinium myrtilloides*	100	1.08	0.767	7
VAVI	*Vaccinium vitis-idaea*	100	0.748	0.469	9
RUST	*Rubus strigosus*	88	0.692	0.614	10
ARUV	*Arctostaphylos uva-ursi*	40	0.488	1.03	11
PRPE	*Prunus pensylvanica*	32	0.300	0.577	15
LEGR	*Ledum groenlandicum*	24	0.240	0.502	19
LODI	*Lonicera dioica*	8	0.0044	0.020	33
AMAL	*Amelanchier alnifolia*	8	0.0044	0.020	37
	Total Shrub Cover = 12.56%				
Forbs					
ARNU	*Aralia nudicaulis*	100	5.32	2.70	3
LIBO	*Linnaea borealis*	100	1.96	1.19	4
MACA	*Maianthemum canadense*	100	0.884	0.432	8
COCA	*Cornus canadensis*	100	0.384	0.793	13
EPAN	*Epilobium angustifolium*	40	0.248	0.407	17

continued...

Reference Stand No. 3 Continued

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
VIRE	*Viola renifolia*	64	0.173	0.257	20
RUPU	*Rubus pubescens*	48	0.136	0.212	23
PYSE	*Pyrola secunda*	56	0.097	0.159	24
GABO	*Galium boreale*	64	0.085	0.134	25
GELI	*Geocaulon lividum*	40	0.054	0.138	26
FRVI	*Fragaria virginiana*	12	0.028	0.102	29
PYVI	*Pyrola virens*	24	0.0096	0.027	31
HICA	*Hieracium canadense*	20	0.0056	0.020	32
VIAD	*Viola adunca*	8	0.0044	0.020	35
ANPA	*Anemone patens*	8	0.0044	0.020	36
ACRU	*Actaea rubra*	4	0.0040	0.020	38
CARO	*Campanula rotundifolia*	28	0.0028	0.005	39
LIPH	*Lilium philadelphicum*	8	0.0008	0.003	42
MELI	*Melampyrum lineare*	4	0.0004	0.002	43
ANMU	*Anemone multifida*	4	0.0004	0.002	44
	Total Forb Cover = 9.40%				
Graminoids					
ELIN	*Elymus innovatus*	100	0.360	0.238	14
SCPU	*Schizachne purpurascens*	4	0.020	0.100	30
CXUM	*Carex umbellata*	8	0.0044	0.020	34
ORPU	*Oryzopsis pungens*	20	0.0020	0.004	40
	Total Graminoid Cover = 0.39%				
Pteridophytes					
LYAN	*Lycopodium annotinum*	36	0.268	0.558	16
LYTR	*Lycopodium tristachyum*	20	0.124	0.298	23
DRSP	*Dryopteris spinulosum*	24	0.040	0.104	28
EQVA	*Equisetum variegatum*	8	0.0008	0.003	41
	Total Pteridophyte Cover = 0.43%				
Bryophytes					
PLE SCH	*Pleurozium schreberi*	100	48.2	16.5	1
PTI C-C	*Ptilium crista-castrensis*	96	8.12	8.96	2
HYL SPL	*Hylocomium splendens*	100	6.20	4.63	3
DIC POL	*Dicranum polysetum*	88	0.456	0.610	4
ORT FLA	*Orthodicranum flagellare*	68	0.436	0.624	5
PTI PUL	*Ptilidium pulcherrimum*	68	0.144	0.390	6
BRA SAL	*Brachythecium salebrosum*	80	0.076	0.043	9

continued...

Reference Stand No. 3 Concluded

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
POL JUN	*Polytrichum juniperinum*	12	0.048	0.200	11
DIC SCO	*Dicranum scoparium*	4	0.0040	0.020	20
PLA CUS	*Plagiomnium cuspidatum*	4	0.0004	0.002	22
	Total Bryophyte Cover = 63.69%				
Terrestrial Lichens					
CLA MIT	*Cladina mitis*	20	0.128	0.438	7
CET PIN	*Cetraria pinastri*	80	0.080	0.041	8
CLA CON	*Cladonia coniocraea*	72	0.068	0.047	10
CLA DHL	*Cladonia chlorophaea*	52	0.041	0.049	12
CLA COR	*Cladonia cornuta*	16	0.012	0.033	13
CLA GRA	*Cladonia gracilis*	16	0.012	0.033	14
PEL RUF	*Peltigera rufescens*	12	0.0084	0.028	15
CLA CEN	*Cladonia cenotea*	12	0.0084	0.028	16
CLA GON	*Cladonia gonecha*	8	0.0080	0.028	17
CLA STE	*Cladina stellaris*	4	0.0040	0.020	18
PEL APH	*Peltigera aphthosa*	4	0.0040	0.020	19
ICM ERI	*Icmadophila ericetorum*	4	0.0004	0.002	21
	Total Terrestrial Lichen Cover = 0.38%				

SEADYN PROJECT — HONDO - LESSER SLAVE LAKE AREA

Reference Stand No. 4 Survey Date: Vas. 1981-8-18, Bry. 1981-6-10

Habitat Type: *Picea glauca* [*Pinus banksiana*] on aeolian sand

Sociation Name: PIGL/ABBA/LIBO/HYL SPL

Vascular Plants	Species Richness = 39	Cover = 47.20%
Bryophytes	Species Richness = 13	Cover = 69.10%
Terrestrial Lichens	Species Richness = 9	Cover = 0.46%
Plant Community	Species Richness = 61	Cover = 116.76%

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
Trees					
ABBA	*Abies balsamea*	100	23.48	13.02	1
PIGL	*Picea glauca*	96	17.80	10.02	2
PIBA	*Pinus banksiana*	36	1.00	2.00	3
POTR	*Populus tremuloides*	52	0.854	2.21	5
PIMA	*Picea mariana*	16	0.560	1.33	7
BEPA	*Betula papyrifera*	24	0.321	0.977	9
	Total Tree Cover = 44.02%				
Shrubs					
VIED	*Viburnum edule*	64	0.272	0.467	10
VAMY	*Vaccinium myrtilloides*	64	0.058	0.103	16
LODI	*Lonicera dioica*	24	0.049	0.139	18
LEGR	*Ledum groenlandicum*	8	0.024	0.101	22
ROAC	*Rosa acicularis*	32	0.014	0.033	23
RIGL	*Ribes glandulosum*	4	0.0040	0.020	28
VAVI	*Vaccinium vitis-idaea*	4	0.0040	0.020	29
RITR	*Ribes triste*	4	0.0040	0.020	31
VACA	*Vaccinium caespitosum*	4	0.0004	0.002	35
LOIN	*Lonicera involucrata*	4	0.0004	0.002	37
	Total Shrub Cover = 0.43%				
Forbs					
LIBO	*Linnaea borealis*	90	0.980	1.13	4
COCA	*Cornus canadensis*	100	0.668	0.659	6
ARNU	*Aralia nudicaulis*	56	0.360	0.709	8
MACA	*Maianthemum canadense*	100	0.244	0.243	11
TRBO	*Trientalis borealis*	56	0.122	0.197	12

continued...

Reference Stand No. 4 Continued

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
RUPU	*Rubus pubescens*	16	0.068	0.219	13
GORE	*Goodyera repens*	88	0.066	0.046	14
VIRE	*Viola renifolia*	64	0.062	0.103	15
PYSE	*Pyrola secunda*	52	0.050	0.104	17
PYVI	*Pyrola virens*	68	0.048	0.103	19
GABO	*Galium boreale*	40	0.027	0.100	20
PEPA	*Petasites palmatus*	28	0.024	0.043	21
MINU	*Mitella nuda*	20	0.013	0.007	24
MEPA	*Mertensia paniculata*	8	0.0044	0.020	25
FRVI	*Fragaria virginiana*	8	0.0044	0.004	26
ACRU	*Actaea rubra*	4	0.0040	0.020	30
GELI	*Geocaulon lividum*	4	0.0004	0.002	39
	Total Forb Cover = 2.75%				
Graminoids					
ELIN	*Elymus innovatus*	24	0.0024	0.004	33
CACA	*Calamagrostis canadensis*	20	0.0020	0.004	34
	Total Graminoid Cover = 0.0044%				
Pteridophytes					
LYOB	*Lycopodium obscurum*	8	0.0044	0.020	27
EQPR	*Equisetum pratense*	32	0.0032	0.005	32
EQAR	*Equisetum arvense*	4	0.0004	0.002	36
LYTR	*Lycopodium tristachyum*	4	0.0004	0.002	38
	Total Pteridophyte Cover = 0.0084%				
Bryophytes					
HYL SPL	*Hylocomium splendens*	100	35.20	13.96	1
PLE SCH	*Pleurozium schreberi*	100	17.20	11.55	2
PTI C-C	*Ptilium crista-castrensis*	96	15.84	11.08	3
PTI PUL	*Ptilidium pulcherrimum*	76	0.184	0.310	5
EUR PUL	*Eurhynchium pulchellum*	76	0.184	0.310	6
BRA SAL	*Brachythecium salebrosum*	60	0.165	0.430	7
ORT FLA	*Orthodicranum flagellare*	56	0.128	0.267	8
PLA CUS	*Plagiomnium cuspidatum*	36	0.104	0.273	10
DIC POL	*Dicranum polysetum*	36	0.070	0.199	11
PYL POL	*Pylaisiella polyantha*	12	0.012	0.033	15
DRE UNC	*Drepanocladus uncinatus*	8	0.0080	0.028	16
RHY TRI	*Rhytidiadelphus triquetrus*	4	0.0040	0.020	19
POL JUN	*Polytrichum juniperinum*	4	0.0004	0.002	21
	Total Bryophyte Cover = 69.10%				

continued...

Reference Stand No. 4 Concluded

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
Terrestrial Lichens					
PEL RUF	*Peltigera rufescens*	44	0.185	0.466	4
CLA CON	*Cladonia coniocraea*	52	0.120	0.269	9
CLA CHL	*Cladonia chlorophaea*	68	0.054	0.049	12
PEL HOR	*Peltigera horizontalis*	4	0.052	0.200	13
CET PIN	*Cetraria pinastri*	48	0.034	0.047	14
CLA MUL	*Cladonia multiformis*	8	0.0080	0.028	17
CLA COR	*Cladonia cornuta*	8	0.0080	0.028	18
PEL APH	*Peltigera aphthosa*	4	0.0004	0.002	20
CLA GON	*Cladonia gonecha*	4	0.0004	0.002	22

Total Terrestrial Lichen Cover = 0.46%

SEADYN PROJECT — HONDO - LESSER SLAVE LAKE AREA

Reference Stand No. 5 Survey Date: Vas. 1981-8-17, Bry. 1981-6-8

Habitat Type: *Picea glauca* [*Populus tremuloides*] on glacial till

Sociation Name: POTR/PIGL/VIED/ARNU/MEPA/LIBO/BRA SAL

Vascular Plants	Species Richness = 41	Cover = 53.00%
Bryophytes	Species Richness = 13	Cover = 8.86%
Terrestrial Lichens	Species Richness = 8	Cover = 0.17%
Plant Community	Species Richness = 62	Cover = 62.03%

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
Trees					
PIGL	*Picea glauca*	100	17.60	9.43	1
POTR	*Populus tremuloides*	100	10.32	3.59	2
BEPA	*Betula papyrifera*	24	0.128	0.414	25
	Total Tree Cover = 28.05%				
Shrubs					
VIED	*Viburnum edule*	96	1.68	1.47	7
ROAC	*Rosa acicularis*	100	1.12	1.04	11
LOIN	*Lonicera involucrata*	80	0.836	0.874	12
RITR	*Ribes triste*	56	0.177	0.270	22
LODI	*Lonicera dioica*	64	0.137	0.191	24
AMAL	*Amelanchier alnifolia*	16	0.064	0.220	29
VAVI	*Vaccinium vitis-idaea*	8	0.040	0.138	30
RUST	*Rubus strigosus*	4	0.020	0.100	33
RILA	*Ribes lacustre*	36	0.014	0.033	34
SYAL	*Symphoricarpos albus*	4	0.0040	0.020	37
RIGL	*Ribes glandulosum*	8	0.0008	0.003	40
PRPE	*Prunus pensylvanica*	4	0.0004	0.002	41
	Total Shrub Cover = 4.09%				
Forbs					
LIBO	*Linnaea borealis*	100	5.12	3.24	3
ARNU	*Aralia nudicaulis*	100	3.48	1.45	4
MINU	*Mitella nuda*	100	2.24	1.32	5
MEPA	*Mertensia paniculata*	100	1.94	0.905	6
COCA	*Cornus canadensis*	100	1.58	1.02	8
RUPU	*Rubus pubescens*	100	1.54	1.07	9

continued...

Reference Stand No. 5 Continued

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
ASCI	*Aster ciliolatus*	100	1.12	0.659	10
VIRE	*Viola renifolia*	100	0.780	0.572	13
PEPA	*Petasites palmatus*	96	0.492	0.446	14
FRVI	*Fragaria virginiana*	96	0.369	0.283	15
MACA	*Maianthemum canadense*	92	0.360	0.314	16
ASCO	*Aster conspicuus*	56	0.332	0.490	17
PYAS	*Pyrola asarifolia*	88	0.324	0.353	18
GABO	*Galium boreale*	100	0.232	0.236	20
EPAN	*Epilobium angustifolium*	56	0.192	0.300	21
TRBO	*Trientalis borealis*	32	0.156	0.334	23
ACRU	*Actaea rubra*	40	0.084	0.162	26
GATR	*Galium triflorum*	28	0.072	0.164	27
LAOC	*Lathyrus ochroleucus*	56	0.070	0.137	28
ACMI	*Achillea millefolium*	52	0.027	0.042	32
PYSE	*Pyrola secunda*	16	0.012	0.033	35
GORE	*Goodyera repens*	8	0.0044	0.020	36
FRVE	*Fragaria vesca*	4	0.0040	0.020	38
	Total Forb Cover = 20.53%				
Graminoids					
CACA	*Calamagrostis canadensis*	92	0.270	0.436	19
ELIN	*Elymus innovatus*	16	0.028	0.102	31
	Total Graminoid Cover = 0.30%				
Pteridophytes					
EQSY	*Equisetum sylvaticum*	28	0.0028	0.005	39
	Total Pteridophyte Cover = 0.0028%				
Bryophytes					
BRA SAL	*Brachythecium salebrosum*	100	3.44	0.961	1
PLE SCH	*Pleurozium schreberi*	72	1.90	5.93	2
PLA CUS	*Plagiomnium cuspidatum*	100	1.30	1.04	3
HYL SPL	*Hylocomium splendens*	96	0.952	0.967	4
EUR PUL	*Eurhynchium pulchellum*	92	0.572	0.675	5
PTI C-C	*Ptilium crista-castrensis*	76	0.436	0.553	6
PYL POL	*Pylaisiella polyantha*	80	0.116	0.189	8
DRE UNC	*Drepanocladus uncinatus*	64	0.064	0.049	9
PTI PUL	*Ptilidium pulcherrimum*	16	0.052	0.200	10
THU REC	*Thuidium recognitum*	12	0.012	0.033	12

continued...

Reference Stand No. 5 Concluded

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
HEP sp	Hepatic species	8	0.0080	0.028	13
DIC POL	*Dicranum polysetum*	8	0.0044	0.020	14
RHY TRI	*Rhytidiadelphus triquetrus*	4	0.0040	0.020	18
	Total Bryophyte Cover = 8.86%				
Terrestrial Lichens					
PEL RUF	*Peltigera rufescens*	68	0.140	0.263	7
CLA CHL	*Cladonia chlorophaea*	20	0.016	0.037	11
CLA MUL	*Cladonia multiformis*	8	0.0044	0.020	15
CLA CEN	*Cladonia cenotea*	8	0.0044	0.020	16
CLA GRA	*Cladonia gracilis*	4	0.0040	0.020	17
CLA CON	*Cladonia coniocraea*	8	0.0008	0.003	19
PEL APH	*Peltigera aphthosa*	4	0.0004	0.002	20
PEL POL	*Peltigera polydactyla*	4	0.0004	0.002	21
	Total Terrestrial Lichen Cover = 0.17%				

SEADYN PROJECT — HONDO - LESSER SLAVE LAKE AREA

Reference Stand No. 6 Survey Date: Vas. 1981-8-17, Bry. 1981-6-8

Habitat Type: *Picea glauca* [*Populus tremuloides*] on glacial till

Sociation Name: PIGL/ABBA/LOIN/ARNU/MEPA/LIBO/PLE SCH

Vascular Plants	Species Richness = 54	Cover = 56.71%
Bryophytes	Species Richness = 13	Cover = 16.08%
Terrestrial Lichens	Species Richness = 10	Cover 0.37%
Plant Community	Species Richness = 77	Cover = 73.16%

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
Trees					
PIGL	*Picea glauca*	100	13.48	9.61	1
ABBA	*Abies balsamea*	84	11.16	11.65	2
POTR	*Populus tremuloides*	80	5.00	5.07	3
BEPA	*Betula papyrifera*	8	0.160	0.624	24
POBA	*Populus balsamifera*	4	0.120	0.600	30
	Total Tree Cover = 29.92%				
Shrubs					
LOIN	*Lonicera involucrata*	100	2.72	1.57	6
ROAC	*Rosa acicularis*	100	1.82	1.11	8
VIED	*Viburnum edule*	100	1.34	1.01	11
RITR	*Ribes triste*	64	0.228	0.307	18
RUST	*Rubus strigosus*	24	0.128	0.297	27
AMAL	*Amelanchier alnifolia*	48	0.117	0.199	31
LODI	*Lonicera dioica*	48	0.112	0.230	32
LEGR	*Ledum groenlandicum*	4	0.040	0.200	36
RILA	*Ribes lacustre*	44	0.030	0.045	37
SYAL	*Symphoricarpos albus*	16	0.012	0.033	40
VAVI	*Vaccinium vitis-idaea*	8	0.0080	0.028	43
RIGL	*Ribes glandulosum*	4	0.0040	0.020	45
SHCA	*Shepherdia canadensis*	4	0.0004	0.002	53
PRPE	*Prunus pensylvanica*	4	0.0004	0.020	54
	Total Shrub Cover = 6.56%				
Forbs					
ARNU	*Aralia nudicaulis*	80	4.46	4.95	4
LIBO	*Linnaea borealis*	100	3.62	2.17	5
MEPA	*Mertensia paniculata*	100	2.32	1.51	7

continued...

Reference Stand No. 6 Continued

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
COCA	*Cornus canadensis*	100	1.73	1.27	9
RUPU	*Rubus pubescens*	100	1.57	1.36	10
ASCI	*Aster ciliolatus*	100	1.22	1.07	12
MINU	*Mitella nuda*	100	1.21	0.817	13
PEPA	*Petasites palmatus*	100	0.888	0.799	14
VIRE	*Viola renifolia*	84	0.504	0.488	16
ACRU	*Actaea rubra*	56	0.240	0.314	17
FRVI	*Fragaria virginiana*	80	0.228	0.293	19
GATR	*Galium triflorum*	72	0.204	0.256	20
DITR	*Disporum trachycarpum*	8	0.164	0.799	21
LAOC	*Lathyrus ochroleucus*	60	0.164	0.284	22
GABO	*Galium boreale*	100	0.160	0.152	23
PYAS	*Pyrola asarifolia*	56	0.140	0.238	25
ASCO	*Aster conspicuus*	28	0.132	0.295	26
FRVE	*Fragaria vesca*	44	0.124	0.196	28
EPAN	*Epilobium angustifolium*	44	0.121	0.245	29
MACA	*Maianthemum canadense*	64	0.092	0.132	33
ACMI	*Achillea millefolium*	64	0.074	0.136	34
TRBO	*Trientalis borealis*	44	0.046	0.104	35
AQBR	*Aquilegia brevistyla*	4	0.020	0.100	39
HICA	*Hieracium canadense*	16	0.0052	0.020	44
PYSE	*Pyrola secunda*	4	0.0040	0.020	46
PYVI	*Pyrola virens*	4	0.0040	0.020	47
VIAM	*Vicia americana*	12	0.0012	0.003	50
GORE	*Goodyera repens*	8	0.0008	0.003	52
	Total Forb Cover = 19.45%				
Graminoids					
CACA	*Calamagrostis canadensis*	100	0.729	0.830	15
ELGL	*Elymus glaucus*	8	0.020	0.100	38
ELIN	*Elymus innovatus*	12	0.0084	0.028	42
AGsp	*Agropyron* sp.	4	0.0040	0.020	48
SCPU	*Schizachne purpurascens*	4	0.0040	0.020	49
BRCI	*Bromus ciliolatus*	8	0.0008	0.003	51
	Total Graminoid Cover = 0.77%				
Pteridophytes					
EQSY	*Equisetum sylvaticum*	20	0.0092	0.028	41
	Total Pteridophyte Cover = 0.0092%				

continued...

Reference Stand No. 6 Concluded

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
Bryophytes					
PLE SCH	*Pleurozium schreberi*	96	5.68	5.35	1
HYL SPL	*Hylocomium splendens*	100	3.52	1.45	2
PTI C-C	*Ptilium crista-castrensis*	96	2.67	3.06	3
BRA SAL	*Brachythecium salebrosum*	100	1.84	0.688	4
PLA CUS	*Plagiomnium cuspidatum*	88	1.37	1.10	5
EUR PUL	*Eurhynchium pulchellum*	96	0.716	0.587	6
PYL POL	*Pylaisiella polyantha*	68	0.093	0.195	9
DRE UNC	*Drepanocladus uncinatus*	24	0.060	0.200	10
THU REC	*Thuidium recognitum*	24	0.053	0.200	11
AUL PAL	*Aulacomnium palustre*	4	0.044	0.200	12
ORT FLA	*Orthodicranum flagellare*	20	0.016	0.037	13
DIC POL	*Dicranum polysetum*	8	0.0080	0.028	15
PTI PUL	*Ptilidium pulcherrimum*	8	0.0040	0.020	19
	Total Bryophyte Cover = 16.08%				
Terrestrial Lichens					
PEL RUF	*Peltigera rufescens*	56	0.196	0.361	7
PEL HOR	*Peltigera horizontalis*	16	0.124	0.439	8
CLA CHL	*Cladonia chlorophaea*	48	0.016	0.032	14
CLA CON	*Cladonia coniocraea*	8	0.0080	0.028	16
PEL POL	*Peltigera polydactyla*	8	0.0080	0.028	17
CLA GRA	*Cladonia gracilis*	8	0.0044	0.020	18
PEL APH	*Peltigera aphthosa*	4	0.0040	0.020	20
PEL PUL	*Peltigera pulverulenta*	4	0.0040	0.020	21
CLA CAP	*Cladonia capitata*	8	0.0008	0.003	22
LEP SAT	*Leptogium saturninum*	4	0.0004	0.002	23
	Total Terrestrial Lichen Cover = 0.37%				

SEADYN PROJECT — HONDO - LESSER SLAVE LAKE AREA

Reference Stand No. 7 Survey Date: Vas. 1981-8-18, Bry. 1981-6-10

Habitat Type: *Picea mariana* [*Larix laricina*] on peatland

Sociation Name: PIMA/LEGR/CXRO/CXGY/TOM NIT

Vascular Plants	Species Richness = 40	Cover = 42.91%
Bryophytes	Species Richness = 17	Cover = 70.18%
Terrestrial Lichens	Species Richness = 20	Cover = 3.54%
Plant Community	Species Richness = 77	Cover = 116.63%

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
Trees					
PIMA	*Picea mariana*	100	21.88	6.71	1
LALA	*Larix laricina*	72	1.30	2.79	7
	Total Tree Cover = 23.18%				
Shrubs					
LEGR	*Ledum groenlandicum*	88	4.06	3.63	2
BEPU	*Betula pumila*	100	2.92	2.57	3
SAMY	*Salix myrtillifolia*	72	1.22	1.33	8
ANPO	*Andromeda polifolia*	100	1.11	1.07	9
SAPE	*Salix pedicellaris*	96	0.596	0.567	12
OXMI	*Oxycoccus microcarpus*	88	0.534	0.642	13
SACA	*Salix candida*	92	0.504	0.707	14
VAVI	*Vaccinium vitis-idaea*	24	0.108	0.287	19
SAGL	*Salix glauca*	16	0.048	0.139	23
SAAR	*Salix arbusculoides*	4	0.040	0.200	26
LOVI	*Lonicera villosa*	8	0.0080	0.028	33
	Total Shrub Cover = 11.15%				
Forbs					
SMTR	*Smilacina trifolia*	100	1.59	1.03	6
METR	*Menyanthes trifoliata*	92	1.08	0.886	10
POPA	*Potentilla palustris*	28	0.148	0.304	17
GELI	*Geocaulon lividum*	32	0.053	0.138	21
CARO	*Campanula rotundifolia*	92	0.052	0.047	22
ORRO	*Orchis rotundifolia*	36	0.045	0.104	24
PYSE	*Pyrola secunda*	36	0.041	0.104	25
DRRO	*Drosera rotundifolia*	32	0.034	0.103	27

continued...

Reference Stand No. 7 Continued

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
RUAC	*Rubus acaulis*	8	0.024	0.101	28
MINU	*Mitella nuda*	28	0.021	0.041	29
SPRO	*Spiranthes romanzoffiana*	32	0.018	0.037	30
PAPA	*Parnassia palustris*	40	0.015	0.032	31
GALA	*Galium labradoricum*	56	0.013	0.027	32
PYVI	*Pyrola virens*	8	0.0044	0.020	34
TOGL	*Tofieldia glutinosa*	16	0.0016	0.004	36
ASJU	*Aster junciformis*	16	0.0016	0.004	37
COTR	*Corallorhiza trifida*	4	0.0004	0.002	38
HAOB	*Habenaria obtusata*	4	0.0004	0.002	40
	Total Forb Cover - 3.14%				
Graminoids					
CXGY	*Carex gynocrates*	100	2.17	2.03	4
CXRO	*Carex rostrata*	100	1.82	1.49	5
CXDI	*Carex diandra*	84	0.888	0.885	11
CXIN	*Carex interior*	24	0.200	0.479	15
TRMA	*Triglochin maritima*	80	0.151	0.250	16
CXLI	*Carex limosa*	4	0.0040	0.020	35
CAIN	*Calamagrostis inexpansa*	4	0.0004	0.002	39
	Total Graminoid Cover = 5.23%				
Pteridophytes					
EQSC	*Equisetum scirpoides*	100	0.125	0.225	18
EQFL	*Equisetum fluviatile*	80	0.081	0.162	20
	Total Pteridophyte Cover = 0.21%				
Bryophytes					
TOM NIT	*Tomenthypnum nitens*	100	32.0	15.3	1
AUL PAL	*Aulacomnium palustre*	100	25.2	10.7	2
SPH NEM	*Sphagnum nemoreum*	64	3.57	5.19	3
SPH FUS	*Sphagnum fuscum*	48	3.40	5.62	4
HYL SPL	*Hylocomium splendens*	56	1.56	2.31	6
PLE SCH	*Pleurozium schreberi*	44	1.25	3.06	7
SPH ANG	*Sphagnum angustifolium*	40	1.20	2.40	8
SPH WAR	*Sphagnum warnstorfii*	40	0.964	1.57	9
DIC UND	*Dicranum undulatum*	48	0.344	0.616	11
BRY PSE	*Bryum pseudotriquetrum*	56	0.312	0.526	12
HEL BLA	*Helodium blandowii*	4	0.160	0.800	16
DRE REV	*Drepanocladus revolvens*	36	0.144	0.325	17

continued...

Reference Stand No. 7 Concluded

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
PLA CUS	*Plagiomnium cuspidatum*	12	0.120	0.033	23
PTI C-C	*Ptilium crista-castrensis*	4	0.040	0.200	25
POL JUN	*Polytrichum juniperinum*	8	0.0080	0.028	30
SPH RUS	*Sphagnum russowii*	4	0.0040	0.020	32
CER PUR	*Ceratodon purpureus*	4	0.0040	0.020	33
	Total Bryophyte Cover = 70.18%				
Terrestrial Lichens					
CLA MIT	*Cladina mitis*	96	1.81	2.05	5
PEL APH	*Peltigera aphthosa*	60	0.652	0.747	10
CLA MUL	*Cladonia multiformis*	88	0.308	0.492	13
PEL MAL	*Peltigera malacea*	36	0.180	0.367	14
PEL RUF	*Peltigera rufescens*	24	0.168	0.372	15
CET PIN	*Cetraria pinastri*	100	0.100	0.000	18
CLA COR	*Cladonia cornuta*	60	0.096	0.195	19
CLA GRA	*Cladonia gracilis*	64	0.064	0.049	20
PEL POL	*Peltigera polydactyla*	20	0.056	0.200	21
CLA CHL	*Cladonia chlorophaea*	48	0.044	0.050	22
CLA PYX	*Cladonia pyxidata*	16	0.016	0.037	24
CLA CRT	*Cladonia cristatella*	16	0.0088	0.028	26
CLA SUB	*Cladonia subulata*	12	0.0084	0.028	27
CLA PHY	*Cladonia phyllophora*	8	0.0080	0.028	28
CLA CRP	*Cladonia crispata*	8	0.0080	0.028	29
CLA CON	*Cladonia coniochraea*	8	0.0044	0.020	31
CLA GON	*Cladonia gonecha*	4	0.0040	0.020	34
CLA CEN	*Cladonia cenotea*	4	0.0004	0.0002	35
CLA FUR	*Cladonia furcata*	4	0.0004	0.002	36
CLA COC	*Cladonia coccifera*	4	0.0004	0.002	37
	Total Terrestrial Lichen Cover = 3.54%				

SEADYN PROJECT — HONDO - LESSER SLAVE LAKE AREA

Reference Stand No. 8 Survey Date: Vas. 1981-8-18, Bry. 1981-6-9

Habitat Type: *Picea mariana* [*Larix laricina*] on peatland

Sociation Name: PIMA/LEGR/PLE SCH

Vascular Plants	Species Richness = 34	Cover = 38.36%
Bryophytes	Species Richness = 13	Cover = 76.30%
Terrestrial Lichens	Species Richness = 15	Cover = 3.11%
Plant Community	Species Richness = 62	Cover = 117.77%

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
Trees					
PIMA	*Picea mariana*	100	30.00	7.21	1
LALA	*Larix laricina*	4	0.080	0.400	15
	Total Tree Cover = 30.08%				
Shrubs					
LEGR	*Ledum groenlandicum*	100	4.76	6.11	2
VAVI	*Vaccinium vitis-idaea*	100	0.472	0.570	3
LOIN	*Lonicera involucrata*	20	0.308	1.21	8
SAMY	*Salix myrtillifolia*	72	0.260	0.440	10
ROAC	*Rosa acicularis*	40	0.157	0.417	11
VAMY	*Vaccinium myrtilloides*	24	0.020	0.041	18
OXMI	*Oxycoccus microcarpus*	44	0.015	0.032	19
LOVI	*Lonicera villosa*	20	0.0092	0.028	21
SABE	*Salix bebbiana*	4	0.0004	0.002	32
	Total Shrub Cover = 6.00%				
Forbs					
RUCH	*Rubus chamaemorus*	20	0.404	1.04	4
SMTR	*Smilacina trifolia*	48	0.332	0.638	7
LIBO	*Linnaea borealis*	52	0.296	0.472	9
PEPA	*Petasites palmatus*	36	0.112	0.200	13
PESA	*Petasites sagittatus*	12	0.104	0.408	14
COCA	*Cornus canadensis*	12	0.044	0.139	16
GELI	*Geocaulon lividum*	16	0.0088	0.028	22
GABO	*Galium boreale*	20	0.0056	0.020	23
MINU	*Mitella nuda*	16	0.0052	0.020	24
EPAN	*Epilobium angustifolium*	8	0.0044	0.020	26

Continued...

Reference Stand No. 8 Continued

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
ASCI	*Aster ciliolatus*	8	0.0044	0.020	27
RUAC	*Rubus acaulis*	4	0.0040	0.020	28
CARO	*Campanula rotundifolia*	20	0.0020	0.004	29
DRRO	*Drosera rotundifolia*	8	0.0008	0.003	30
GAsp	*Galium* sp.	8	0.0008	0.003	31
ACMI	*Achillea millefolium*	4	0.0004	0.002	33
	Total Forb Cover = 1.33%				
Graminoids					
CXGY	*Carex gynocrates*	64	0.402	0.743	5
CXEL	*Carex elegans*	72	0.366	0.816	6
CXAU	*Carex aurea*	20	0.029	0.102	17
ELIN	*Elymus innovatus*	24	0.0096	0.027	20
CACA	*Calamagrostis canadensis*	4	0.0004	0.002	34
	Total Graminoid Cover = 0.81%				
Pteridophytes					
EQSC	*Equisetum scirpoides*	88	0.140	0.237	12
EQAR	*Equisetum arvense*	16	0.0052	0.020	25
	Total Pteridophyte Cover = 0.15%				
Bryophytes					
PLE SCH	*Pleurozium schreberi*	100	47.0	17.0	1
HYL SPL	*Hylocomium splendens*	100	26.2	17.2	2
SPH FUS	*Sphagnum fuscum*	48	1.90	4.47	4
SPH NEM	*Sphagnum nemoreum*	24	0.408	1.12	6
DIC POL	*Dicranum polysetum*	52	0.268	0.422	7
DIC UND	*Dicranum undulatum*	44	0.232	0.568	8
PTI C-C	*Ptilium crista-castrensis*	16	0.200	0.500	9
AUL PUL	*Aulacomnium palustre*	20	0.052	0.200	10
POL JUN	*Polytrichum juniperinum*	20	0.016	0.037	14
POL STR	*Polytrichum strictum*	12	0.0084	0.028	19
TOM NIT	*Tomenthypnum nitens*	4	0.0040	0.020	22
BRY PSE	*Bryum pseudotriquetrum*	4	0.0040	0.020	24
SPH WAR	*Sphagnum warnstorfii*	4	0.0040	0.020	26
	Total Bryophyte Cover = 76.30%				

continued...

Reference Stand No. 8 Concluded

CODE	Species	Frequency % 5x5 m Plots	Plant Cover % Mean	S.D.	Rank
Terrestrial Lichens					
CLA MIT	*Cladina mitis*	88	2.26	4.22	3
PEL APH	*Peltigera aphthosa*	84	0.672	0.671	5
PEL RUF	*Peltigera rufescens*	8	0.044	0.200	11
CLA CHL	*Cladonia chlorophaea*	52	0.030	0.044	12
CLA COR	*Cladonia cornuta*	28	0.021	0.041	13
PEL PUL	*Peltigera pulverulenta*	20	0.016	0.037	15
CLA MUL	*Cladonia multiformis*	16	0.016	0.037	16
PEL MAL	*Peltigera malacea*	12	0.012	0.033	17
CLA GRA	*Cladonia gracilis*	16	0.0088	0.028	18
CLA CRP	*Cladonia crispata*	12	0.0084	0.028	20
PEL POL	*Peltigera polyantha*	8	0.0080	0.028	21
CLA COC	*Cladonia coccifera*	4	0.0040	0.020	23
ICM ERI	*Icmadophila ericetorum*	4	0.0040	0.020	25
CLA STE	*Cladina stellaris*	4	0.0040	0.020	27
CLA CEN	*Cladonia cenotea*	4	0.0004	0.002	28

Total Terrestrial Lichen Cover = 3.11%

sampling units for testing purposes, i.e., there are 24 degrees of freedom. Strictly speaking, these statistics are estimates of the parameters of the reference stand, not of the larger area of the same community in which the reference stand is located. The finite population correction (Snedecor 1956: 498) $f = 0.5$ (defined as the square root of the sampling intensity) may be used in calculating standard errors of the means of plant species when the reference stands are used in hypothesis testing. For example, the standard error of mean *Aralia nudicaulis* cover % in stand no. 3 on 16 August 1981 is

$$s_{\bar{x},\ Arnu} = f(\text{S.D.}/\sqrt{n}\ ),\ \text{i.e. } 0.5(2.70/\sqrt{25}\ ),\ \text{or } \pm 0.27\%.$$

Since f and n are constant for all surveys, the standard error is equal to 0.1(S.D.) in all cases in Table 5.

4.4.2 Synthesis Table

Table 6 is a synthesis condensed from Table 5 to facilitate comparison and interpretation of communities, growth-forms, species, and reference stands. For each of the eight reference stands it gives: (1) the estimated total cover % (in italics) of the five major vascular and two major bryoid growth-form groups, and (2) the estimated mean cover % of each species, on the dates of the respective surveys. Species are arranged in order of their ecological associations with the three habitat types, beginning with those restricted to well drained aeolian sands and ending with those restricted to poorly drained peatlands.

4.4.3 Plant Community Attributes of Reference Stands

Table 7 gives the total cover (%), species richness (R), dominance (D), diversity (H'), maximum diversity (H_{max}), and evenness (E) (see definitions in section 1.2) of the vascular plant and terrestrial 'bryoid' (i.e., bryophyte and lichen) communities in the eight reference stands when they were surveyed in August and June of 1981, respectively.

[Text continued on page 84]

Table 6. Synthesis table showing the estimated % cover of major plant growth-forms[a] and species in the eight reference stands of the Hondo - Lesser Slave Lake area in north central Alberta.

GROWTH-FORM / *Species*	Reference Stand Number							
	Aeolian Sand H.T.				Glacial Till H.T.		Peatland H.T.	
	1	2	3	4	5	6	7	8
TREE	*9.40*	*12.96*	*29.29*	*44.02*	*28.05*	*29.92*	*23.18*	*30.08*
Pinus banksiana	9.34	12.92	26.72	1.00	.	.	.	.
Populus tremuloides	0.04	0.004	0.42	0.85	10.32	5.00	.	.
Picea glauca	0.02	0.04	1.74	17.80	17.60	13.48	.	.
Betula papyrifera	.	.	0.12	0.32	0.13	0.16	.	.
Abies balsamea	.	.	0.04	23.48	.	11.16	.	.
Populus balsamifera	.	.	.	.	.	0.12	.	.
Picea mariana	.	.	0.25	0.56	.	.	21.88	30.00
Larix laricina	.	.	.	.	.	.	1.30	0.08
SHRUB	*27.10*	*31.27*	*12.56*	*0.43*	*4.09*	*6.56*	*11.15*	*6.00*
Arctostaphylos uva-ursi	18.04	13.45	0.49	.	.	.	.	.
Amelanchier alnifolia	0.48	0.47	0.004	.	0.06	0.12	.	.
Shepherdia canadensis	0.08	0.74	.	.	.	0.0004	.	.
Prunus pensylvanica	0.14	0.16	0.30	.	0.0004	0.0004	.	.
Prunus virginiana	.	0.08	.	.	.	.	.	.
Rosa woodsii	.	0.08	.	.	.	.	.	.
Rosa acicularis	0.52	1.90	1.40	0.01	1.12	1.82	.	0.16
Vaccinium myrtilloides	0.72	1.10	1.08	0.06	.	.	.	0.02
Vaccinium vitis-idaea	6.20	7.57	0.75	0.004	0.04	0.01	0.11	0.47
Alnus crispa	0.82	5.58	7.60	.	.	.	.	.

continued...

Table 6. Continued

GROWTH-FORM / Species	Reference Stand Number							
	Aeolian Sand H.T.				Glacial Till H.T.		Peatland H.T.	
	1	2	3	4	5	6	7	8
Rubus strigosus	0.10	0.10	0.69	.	0.02	0.13	.	.
Salix bebbiana	0.08	0.02	.	.	.	.	.	0.0004
Lonicera dioica	.	.	0.004	0.05	0.14	0.11	.	.
Viburnum edule	.	.	.	0.27	1.68	1.34	.	.
Lonicera involucrata	.	.	.	0.0004	0.84	2.72	.	0.31
Ledum groenlandicum	.	.	0.24	0.02	.	0.04	4.06	4.76
Ribes triste	.	.	.	0.004	0.18	0.23	.	.
Ribes glandulosum	.	.	.	0.004	0.001	0.004	.	.
Vaccinium caespitosum	.	.	.	0.0004	.	.	.	.
Ribes lacustre	.	.	.	.	0.01	0.03	.	.
Symphoricarpos albus	.	.	.	.	0.004	0.01	.	.
Betula pumila	.	.	.	.	.	.	2.92	.
Salix myrtillifolia	.	.	.	.	.	.	1.22	0.26
Salix candida	.	.	.	.	.	.	0.50	.
Salix pedicellaris	.	.	.	.	.	.	0.60	.
Salix glauca	.	.	.	.	.	.	0.05	.
Salix arbusculoides	.	.	.	.	.	.	0.04	.
Oxycoccus microcarpus	.	.	.	.	.	.	0.53	0.02
Andromeda polifolia	.	.	.	.	.	.	1.11	.
Lonicera villosa	.	.	.	.	.	.	0.01	0.01
Forb	*2.43*	*3.98*	*9.40*	*2.75*	*20.53*	*19.45*	*3.14*	*1.33*
Antennaria racemosa	0.01	.	.	.	.	.	.	.
Artemisia campestris	0.01	.	.	.	.	.	.	.
Solidago decumbens	0.13	0.23	.	.	.	.	.	.

continued...

Table 6. Continued

GROWTH-FORM / Species	Reference Stand Number							
	Aeolian Sand H.T.				Glacial Till H.T.		Peatland H.T.	
	1	2	3	4	5	6	7	8
Erigeron glabellus	0.03	0.15	.	.	.	.	.	.
Aster laevis	0.48	0.67	.	.	.	.	.	.
Viola adunca	0.03	0.04	0.004	.	.	.	.	.
Lilium philadelphicum	0.001	.	0.001	.	.	.	.	.
Anemone patens	0.02	0.05	0.004	.	.	.	.	.
Anemone multifida	0.06	0.09	0.0004	.	.	.	.	.
Hieracium canadense	0.03	0.02	0.006	.	.	0.01	.	.
Maianthemum canadense	0.45	0.93	0.88	0.24	0.36	0.09	.	.
Galium boreale	0.18	0.14	0.09	0.03	0.23	0.16	.	0.006
Geocaulon lividum	0.10	0.40	0.05	0.0004	.	.	0.05	0.009
Fragaria virginiana	0.03	.	0.03	0.004	0.37	0.23	.	.
Pyrola virens	0.03	0.02	0.01	0.05	.	0.004	0.004	.
Pyrola secunda	0.02	0.07	0.10	0.05	0.01	0.004	0.04	.
Campanula rotundifolia	0.02	0.01	0.003	.	.	.	0.05	0.002
Achillea millefolium	0.0004	.	.	.	0.03	0.07	.	0.0004
Epilobium angustifolium	0.001	.	0.25	.	0.19	0.12	.	0.004
Linnaea borealis	0.80	0.44	1.96	0.98	5.12	3.62	.	0.30
Aralia nudicaulis	.	0.62	5.32	0.36	3.48	4.46	.	.
Melampyrum lineare	.	0.10	0.0004	.	.	.	.	.
Rubus pubescens	.	.	0.14	0.07	1.54	1.57	.	.
Viola renifolia	.	.	0.17	0.06	0.78	0.50	.	.
Actaea rubra	.	.	0.004	0.004	0.08	0.24	.	.
Cornus canadensis	.	.	0.38	0.67	1.58	1.73	.	0.04
Trientalis borealis	.	.	.	0.12	0.16	0.05	.	.
Goodyera repens	.	.	.	0.07	0.004	0.001	.	.

continued...

Table 6. Continued

GROWTH-FORM / Species	Reference Stand Number							
	Aeolian Sand H.T.				Glacial Till H.T.		Peatland H.T.	
	1	2	3	4	5	6	7	8
Petasites palmatus	.	.	.	0.02	0.49	0.89	.	0.11
Mitella nuda	.	.	.	0.01	2.24	1.21	0.02	0.01
Mertensia paniculata	.	.	.	0.004	1.94	2.32	.	.
Aster ciliolatus	.	.	.	.	1.12	1.22	.	0.004
Aster conspicuus	.	.	.	.	0.33	0.13	.	.
Pyrola asarifolia	.	.	.	.	0.32	0.14	.	.
Galium triflorum	.	.	.	.	0.07	0.20	.	.
Lathyrus ochroleucus	.	.	.	.	0.07	0.16	.	.
Fragaria vesca	.	.	.	.	0.004	0.12	.	.
Disporum trachycarpum	.	.	.	.	.	0.16	.	.
Aquilegia brevistyla	.	.	.	.	.	0.02	.	.
Vicia americanaa	.	.	.	.	.	0.001	.	.
Smilacina trifolia	.	.	.	.	.	.	1.59	0.33
Menyanthes trifoliata	.	.	.	.	.	.	1.08	.
Potentilla palustris	.	.	.	.	.	.	0.15	.
Orchis rotundifolia	.	.	.	.	.	.	0.05	.
Drosera rotundifolia	.	.	.	.	.	.	0.03	0.001
Rubus acaulis	.	.	.	.	.	.	0.02	0.004
Spiranthes romanzoffiana	.	.	.	.	.	.	0.02	.
Parnassia palustris	.	.	.	.	.	.	0.02	.
Galium labradoricum	.	.	.	.	.	.	0.01	.
Tofieldia glutinosa	.	.	.	.	.	.	0.002	.
Aster juncifermis	.	.	.	.	.	.	0.002	.
Corallorhiza trifida	.	.	.	.	.	.	0.0004	.
Habenaria obtusata	.	.	.	.	.	.	0.0004	.
Petasites sagittatus	.	.	.	.	.	.	.	0.10
Galium sp.	.	.	.	.	.	.	.	0.001

continued...

Table 6. Continued

GROWTH-FORM / *Species*	Reference Stand Number							
	Aeolian Sand H.T.				Glacial Till H.T.		Peatland H.T.	
	1	2	3	4	5	6	7	8
Graminoid	*1.01*	*0.47*	*0.39*	*0.004*	*0.30*	*0.77*	*5.23*	*0.81*
Carex umbellata	0.50	0.10	0.004	.	.	.	.	.
Carex foenea	0.0004	0.002	.	.	.	.	.	.
Oryzopsis pungens	0.30	0.21	0.002	.	.	.	.	.
Orysopsis asperifolia	0.08	0.01	.	.	.	.	.	.
Elymus glaucus	0.01	0.02	.	.	.	0.02	.	.
Elymus innovatus	0.12	0.13	0.36	0.002	0.03	0.008	.	0.01
Schizachne purpurascens	.	.	0.02	.	.	0.004	.	.
Calamagrostis canadensis	.	.	.	0.002	0.27	0.73	.	0.0004
Agropyron sp.	.	.	.	.	.	0.004	.	.
Bromus ciliolatus	.	.	.	.	.	0.0008	.	.
Calamagrostis inexpansa	.	.	.	.	.	.	0.0004	.
Carex gynocrates	.	.	.	.	.	.	2.17	0.40
Carex rostrata	.	.	.	.	.	.	1.82	.
Carex diandra	.	.	.	.	.	.	0.89	.
Carex interior	.	.	.	.	.	.	0.20	.
Carex limosa	.	.	.	.	.	.	0.004	.
Triglochin maritima	.	.	.	.	.	.	0.15	.
Carex elegans	.	.	.	.	.	.	.	0.37
Carex aurea	.	.	.	.	.	.	.	0.03

continued...

Table 6. Continued

GROWTH-FORM / *Species*	Reference Stand Number							
	Aeolian Sand H.T.				Glacial Till H.T.		Peatland H.T.	
	1	2	3	4	5	6	7	8
Pteridophyte	*0.36*	*0.02*	*0.43*	*0.008*	*0.003*	*0.01*	*0.21*	*0.15*
Equisetum variegatum	0.04	0.01	0.001	.	.	.	.	.
Lycopodium tristachyum	0.32	0.01	0.12	0.0004	.	.	.	.
Equisetum arvense	.	0.004	.	0.0004	.	.	.	0.01
Lycopodium annotinum	.	.	0.001	.	.	.	.	.
Dryopteris spinulosum	.	.	0.04	.	.	.	.	.
Lycopodium obscurum	.	.	.	0.0004	.	.	.	.
Equisetum pratense	.	.	.	0.0004	.	.	.	.
Equisetum sylvaticum	.	.	.	.	0.003	0.01	.	.
Equisetum scirpoides	.	.	.	.	.	.	0.13	0.14
Equisetum fluviatile	.	.	.	.	.	.	0.08	.
Bryophyte	*5.02*	*6.46*	*63.69*	*69.10*	*8.86*	*16.09*	*70.18*	*76.30*
Polytrichum piliferum	0.52	0.10	.	.	.	.	.	.
Ptilidium ciliare	0.0004	0.012	.	.	.	.	.	.
Orthodicranum flagellare	0.004	.	0.44	0.13	.	0.02	.	.
Dicranum scoparium	.	.	0.004	.	.	.	.	.
Polytrichum juniperinum	0.06	0.10	0.05	0.0004	.	.	0.008	0.02
Ceratodon purpureus	.	0.004	.	.	.	.	0.004	.
Pleurozium schreberi	3.09	5.70	48.20	17.20	1.90	5.68	1.25	47.00
Hylocomium splendens	1.25	0.18	6.20	35.20	0.95	3.52	1.56	26.20
Ptilium crista-castrensis	0.06	0.26	8.12	15.84	0.44	2.67	0.04	0.20
Dicranum polysetum	0.04	0.09	0.46	0.07	0.004	0.008	.	0.27
Ptilidium pulcherrimum	.	.	0.14	0.18	0.05	0.004	.	.

continued...

Table 6. Continued

GROWTH-FORM / Species	Reference Stand Number							
	Aeolian Sand H.T.				Glacial Till H.T.		Peatland H.T.	
	1	2	3	4	5	6	7	8
Hepatic sp.	.	.	.	.	0.01	.	.	.
Brachythecium salebrosum	.	.	0.08	0.16	3.44	1.84	.	.
Eurhynchium pulchellum	.	.	.	0.18	0.57	0.72	.	.
Plagiomnium cuspidatum	.	.	0.0004	0.10	1.30	1.37	0.01	.
Pylaisiella polyantha	.	.	.	0.01	0.12	0.09	.	.
Rhytidiadelphus triquetrus	.	.	.	0.004	0.004	.	.	.
Drepanocladus uncinatus	.	.	.	0.01	0.06	0.06	.	.
Thuidium recognitum	.	.	.	.	0.01	0.05	.	.
Aulacomnium palustre	.	.	.	.	.	0.04	25.20	0.05
Tomenthypnum nitens	.	.	.	.	.	.	32.00	0.004
Sphagnum fuscum	.	.	.	.	.	.	3.40	1.90
Sphagnum nemoreum	.	.	.	.	.	.	3.57	0.41
Sphagnum angustifolium	.	.	.	.	.	.	1.20	.
Sphagnum russowii	.	.	.	.	.	.	0.004	.
Sphagnum warnstorfii	.	.	.	.	.	.	0.96	0.004
Dicranum undulatum	.	.	.	.	.	.	0.34	0.23
Drepanocladus revolvens	.	.	.	.	.	.	0.14	.
Bryum pseudotriquetrum	.	.	.	.	.	.	0.31	0.004
Helodium blandowii	.	.	.	.	.	.	0.16	.
Polytrichum strictum	.	.	.	.	.	.	.	0.008

continued...

Table 6. Continued

GROWTH-FORM / *Species*	Reference Stand Number							
	Aeolian Sand H.T.				Glacial Till H.T.		Peatland H.T.	
	1	2	3	4	5	6	7	8
Terrestrial Lichens	*47.88*	*38.55*	*0.38*	*0.46*	*0.17*	*0.37*	*3.54*	*3.11*
Cetraria ericetorum	0.03	0.02	.	.	.	.	.	.
Cetraria nivalis	0.01	0.0004	.	.	.	.	.	.
Cladonia uncialis	0.05	0.06	.	.	.	.	.	.
Stereocaulon alpinum	0.08	.	.	.	.	.	.	.
Cladonia phyllophora	0.56	0.10	.	.	.	.	0.01	.
Cladonia pyxidata	0.07	0.008	.	.	.	.	0.02	.
Peltigera malacea	1.14	2.01	.	.	.	.	0.18	0.01
Cladonia coccifera	0.35	0.07	.	.	.	.	0.0004	0.004
Cladina stellaris	0.01	0.07	0.004	.	.	.	.	0.004
Cladina mitis	44.40	35.72	0.13	.	.	.	1.81	2.26
Icmadophila ericetorum	.	.	0.0004	.	.	.	.	0.004
Cetraria pinastri	0.10	0.07	0.08	0.03	.	.	0.10	.
Cladonia cornuta	0.04	0.06	0.01	0.01	.	.	0.10	0.02
Cladonia gonecha	0.04	.	0.01	0.0004	.	.	0.004	.
Cladonia cristatella	0.01	.	.	.	.	.	0.01	.
Cladonia crispata	.	0.01	.	.	.	.	0.01	0.01
Cladonia subulata	.	.	.	.	.	.	0.01	.
Cladonia furcata	.	.	.	.	.	.	0.0004	.
Peltigera pulverulenta	0.12	0.04	.	.	.	0.004	.	0.02
Cladonia capitata	0.004	.	.	.	.	0.001	.	.
Leptogium saturninum	.	.	.	.	.	0.0004	.	.
Peltigera horizontalis	.	.	.	0.05	.	0.12	.	.
Peltigera polydactyla	.	.	.	.	0.0004	0.008	0.06	0.01

continued...

Table 6. Concluded

GROWTH-FORM *Species*	Reference Stand Number							
	Aeolian Sand H.T.				Glacial Till H.T.		Peatland H.T.	
	1	2	3	4	5	6	7	8
Cladonia cenotea	0.0004	.	0.01	.	0.004	.	0.0004	0.0004
Cladonia gracilis	0.05	0.03	0.01	.	0.004	0.004	0.06	0.01
Cladonia multiformis	0.42	0.10	.	0.01	0.004	.	0.31	0.02
Cladonia chlorophaea	0.18	0.05	0.04	0.05	0.02	0.02	0.04	0.03
Cladonia coniocraea	0.03	0.01	0.07	0.12	0.001	0.01	0.004	.
Peltigera aphthosa	0.18	0.10	0.004	0.0004	0.0004	0.004	0.65	0.67
Peltigera rufescens	0.002	0.01	0.01	0.18	0.14	0.20	0.17	0.04

[a] % cover of growth-forms was calculated as the sum of the mean % cover values of component species and printed in italicized numbers. Complete statistical data in Table 5.

Table 7. Some plant community attributes of the eight SEADYN reference stands in the Hondo - Lesser Slave Lake area of north central Alberta. Dominance and diversity indices calculated from estimated % cover of vascular species surveyed in August 1981 and bryoid species surveyed in June 1981.[a] Attributes defined in section 1.2.

	Reference Stand Number							
	1	2	3	4	5	6	7	8
VASCULAR PLANT COMMUNITY								
Total Cover (%)	40.3	48.7	52.1	47.2	53.0	56.7	42.9	38.4
Species Richness (R)	41	40	44	39	41	54	40	34
Dominance Index (D)	0.28	0.19	0.30	0.39	0.17	0.12	0.28	0.63
Diversity Index (H')	1.76	2.08	1.86	1.29	2.32	2.57	1.98	0.92
Maximum Diversity (H_{max})	3.71	3.69	3.78	3.66	3.71	3.99	3.69	3.53
Evenness Index (E)	0.47	0.56	0.49	0.35	0.63	0.64	0.54	0.26
TERRESTRIAL BRYOPHYTE AND LICHEN COMMUNITY								
Total Cover (%)	52.9	45.0	64.1	69.6	9.0	16.4	73.7	79.4
Species Richness (R)	31	27	22	22	21	23	37	28
Dominance Index (D)	0.71	0.65	0.59	0.37	0.23	0.21	0.31	0.46
Diversity Index (H')	0.79	0.80	0.84	1.13	1.76	1.79	1.54	1.01
Maximum Diversity (H_{max})	3.43	3.30	3.09	3.09	3.04	3.14	3.61	3.33
Evenness Index (E)	0.23	0.24	0.27	0.37	0.58	0.57	0.43	0.30

[a] Estimated % cover of species in Tables 5 and 6.

In terms of vascular plant community attributes, the older of the two reference stands (no. 6) on the *Picea glauca* [*Populus tremuloides*] habitat type had the highest total cover, R, H', H_{max}, and E values, and lowest D. The older of the two reference stands (no. 8) on the *Picea mariana* [*Larix laricina*] habitat type had the lowest total cover, R, H', H_{max}, and E values, and highest D. Younger stands of these two habitat types and all four stands of the *Picea glauca* [*Pinus banksiana*] habitat type had intermediate values of the six community attributes.

In terms of terrestrial bryoid community attributes, the two reference stands on the *Picea mariana* [*Larix laricina*] habitat type had the highest total cover (no. 8) and richness (no. 7), while reference stand no. 6 (see above) had the highest H' and lowest D values. The youngest reference stand (no. 1) on the *Picea glauca* [*Pinus banksiana*] habitat type had the highest D and the lowest H' values.

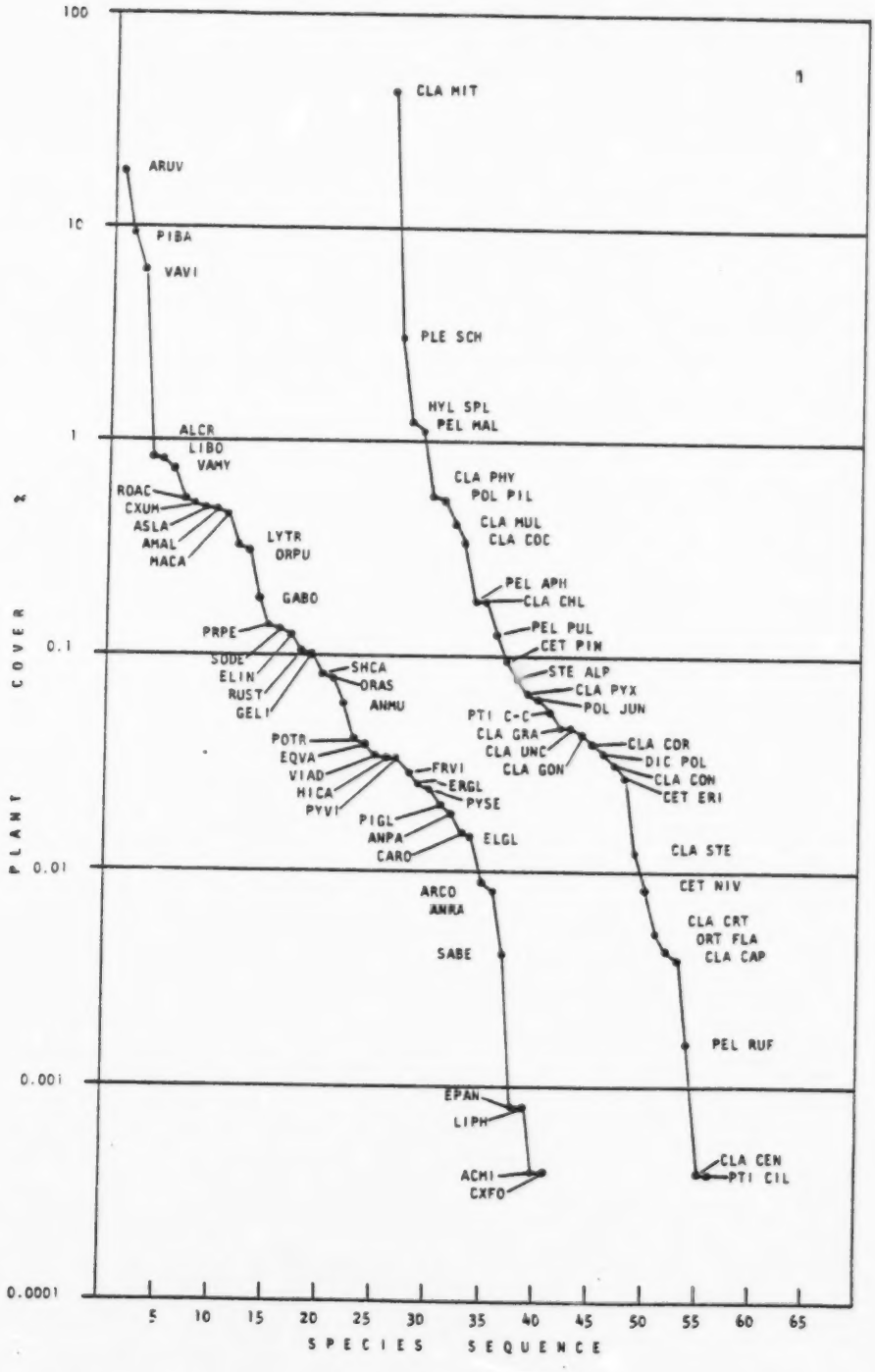
Figure 4 gives the dominance-diversity curves and species dominance hierarchies (see definitions in section 1.2) of the vascular plant and terrestrial bryoid communities in the eight reference stands when surveyed in August and June of 1981, respectively. The curve plots the estimated mean % cover of each species on a logarithmic scale, with species arranged in a sequence of decreasing cover. The dominance hierarchy is shown by identifying the data points on the curve with the four-letter (vascular) or six-letter (bryoid) code names of the species they represent (see Table 5 for code and scientific names of all species).

4.5 SHOOT AND THALLUS COVER DYNAMICS OF PLANT SPECIES IN 1981

Figure 5 shows the estimated mean % cover of (1) selected vascular plant species populations in selected reference stands in August 1980 and during the snow-free season in 1981, and (2) selected terrestrial bryophyte and lichen species populations in selected reference stands from June to the end of the snow-free season in 1981. Vascular shoot data were obtained from 5 x 5 m

[Text continued on page 100]

Figure 4. Species structure curves and species dominance hierarchies for the vascular plant and terrestrial bryophyte and lichen communities of the eight SEADYN reference stands in the Hondo - Lesser Slave Lake area of north central Alberta. The left side of each page contains the vascular component with four-letter species code names placed opposite their estimated mean % cover values in August 1981. The right side of each page contains the terrestrial bryophyte and lichen component with six-letter species code names opposite their estimated mean % cover values in June 1981. Full scientific names of all species are given in Table 5, p 48. For details see sections 1.2 and 4.4. Reference stand numbers appear at the upper right of pages.


100
10
1
0.1
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0.0001
PLANT COVER %
CLA MIT
ARUV
PIBA
VAVI
PLE SCH
HYL SPL
PEL MAL
ALCR
LIBO
VAMY
ROAC
CXUM
ASLA
AMAL
MACA
LYTR
ORPU
GABO
CLA PHY
POL PIL
CLA MUL
CLA COC
PEL APH
CLA CHL
PEL PUL
CET PIN
PRPE
SUDE
ELIN
RUST
GELI
SHCA
ORAS
ANMU
STE ALP
CLA PYX
POL JUN
PTI C-C
CLA GRA
CLA UNC
CLA GON
CLA COR
DIC POL
CLA CON
CET ERI
POTR
EQVA
VIAD
HICA
PYVI
FRVI
ERGL
PYSE
PIGL
ANPA
CARO
ELGL
CLA STE
CET NIV
ARCO
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SABE
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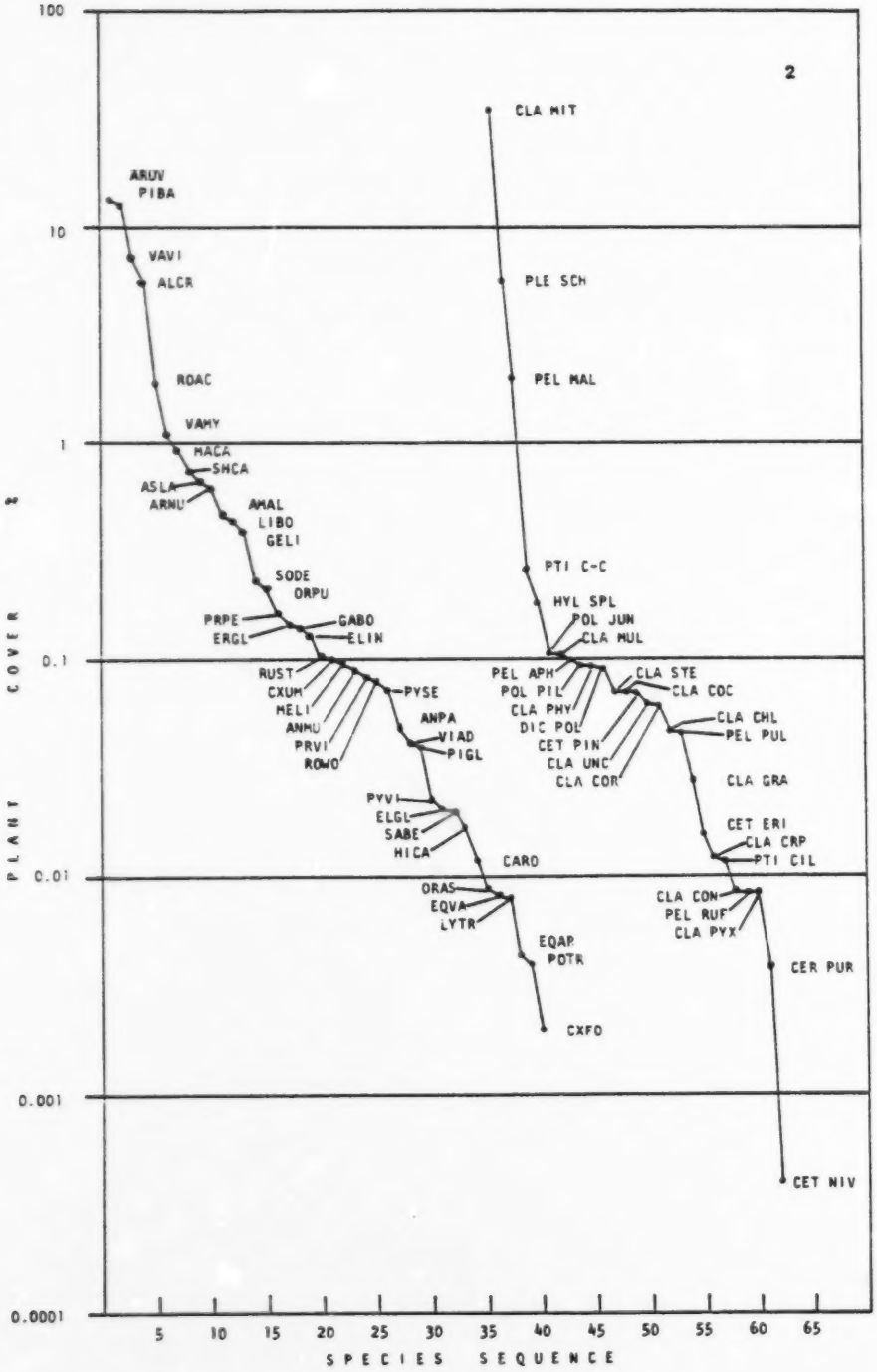
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ALCR
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VAMY
MACA
SHCA
ASLA
ARNU
AMAL
LIBO
GELI
SODE
ORPU
PRPE
ERGL
GABO
ELIN
RUST
CXUM
MELI
ANMU
PRVI
ROMO
PYSE
ANPA
VIAD
PIGL
PYVI
ELGL
SABE
HICA
CARO
ORAS
EQVA
LYTR
EQAR
POTR
CXFO
CLA MIT
PLE SCH
PEL MAL
PTI C-C
HYL SPL
POL JUN
CLA MUL
PEL APH
POL PIL
CLA PHY
DIC POL
CET PIN
CLA UNC
CLA COR
CLA STE
CLA COC
CLA CHL
PEL PUL
CLA GRA
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CLA CRP
PTI CIL
CLA CON
PEL RUF
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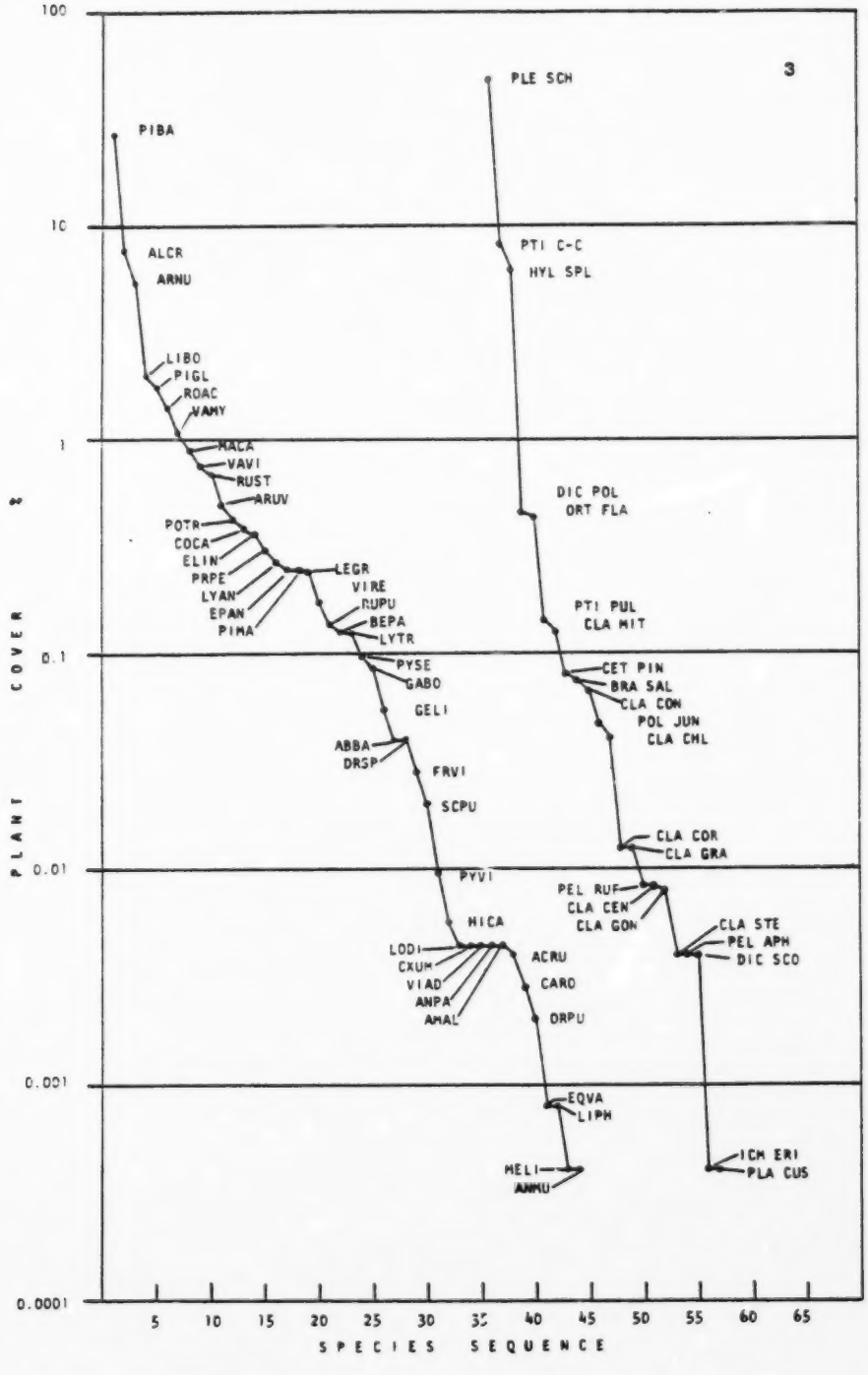
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PLANT COVER %
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VAMY
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VAVI
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ARUV
DIC POL
ORT FLA
POTR
COCA
ELIN
PRPE
LYAN
EPAN
PIMA
LEGR
VIRE
RUPU
BEPA
LYTR
PTI PUL
CLA MIT
PYSE
GABO
GELI
CET PIN
BRA SAL
CLA CON
POL JUN
CLA CHL
ABBA
DRSP
FRVI
SCPU
CLA COR
CLA GRA
PYVI
PEL RUF
CLA CEN
CLA GON
HICA
CLA STE
PEL APH
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LODI
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CARO
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LIPH
ICM ERI
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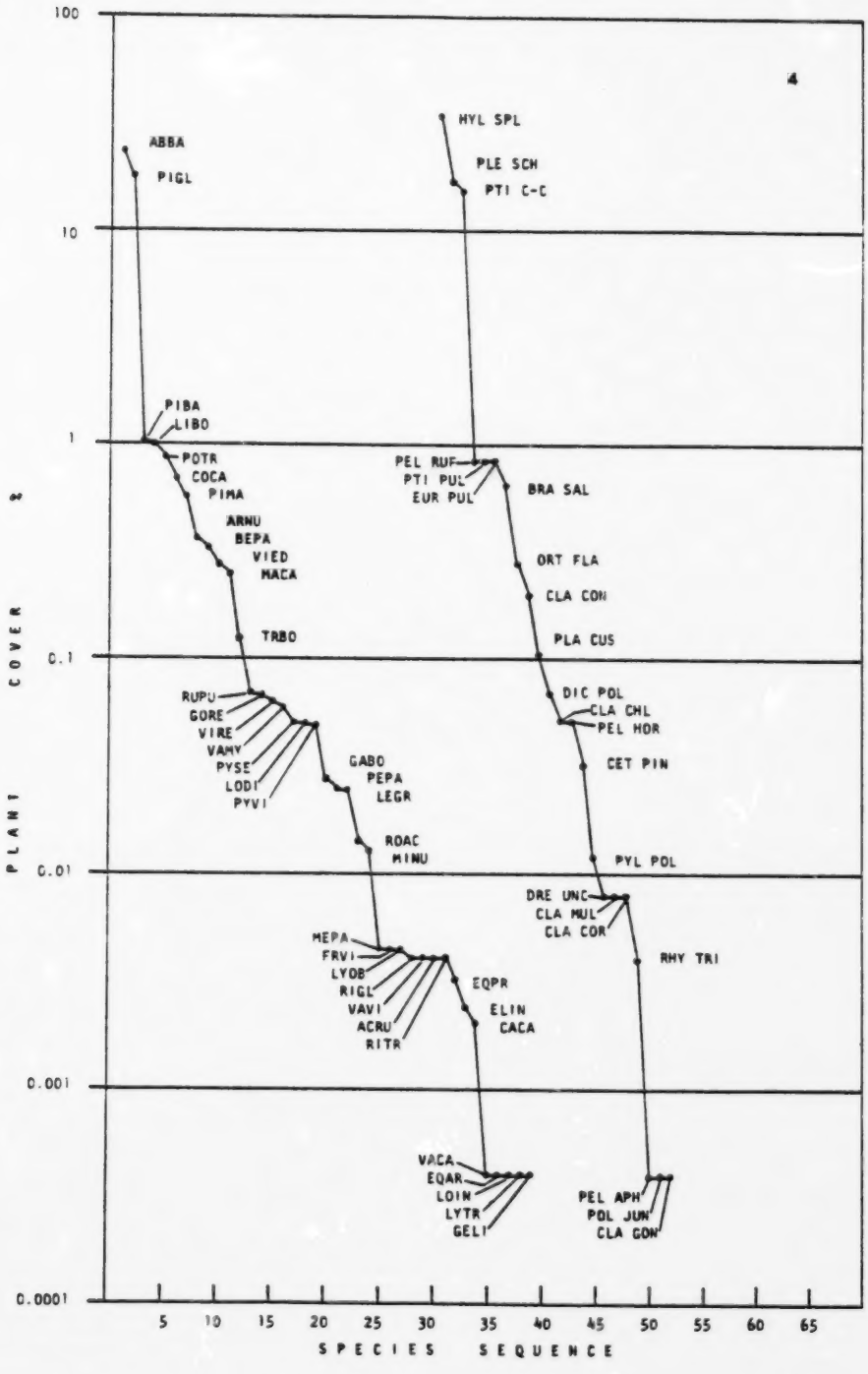
4
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PLANT COVER %
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PIGL
HYL SPL
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PIBA
LIBO
POTR
COCA
PIMA
ARNU
BEPA
VIED
MACA
TRBO
PEL RUF
PTI PUL
EUR PUL
BRA SAL
ORT FLA
CLA CON
PLA CUS
RUPU
GORE
VIRE
VAMY
PYSE
LODI
PYVI
GABO
PEPA
LEGR
ROAC
MINU
DIC POL
CLA CHL
PEL HOR
CET PIN
PYL POL
DRE UNC
CLA MUL
CLA COR
RHY TRI
MEPA
FRVI
LYOB
RIGL
VAVI
ACRU
RITR
EQPR
ELIN
CACA
VACA
EQAR
LOIN
LYTR
GELI
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POL JUN
CLA GON
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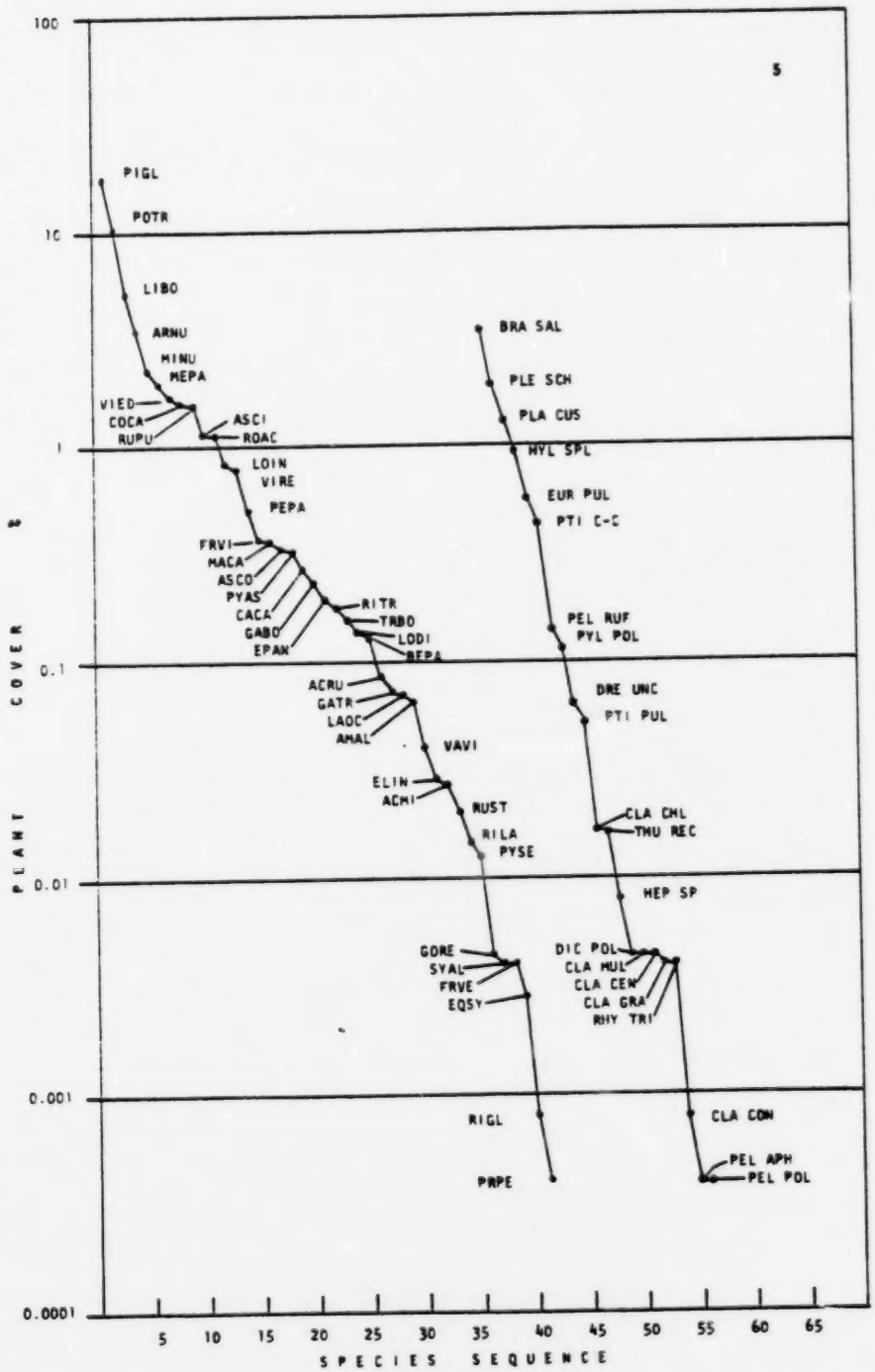
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PLANT COVER %
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PIGL
POTR
LIBO
ARNU
MINU
MEPA
VIED
COCA
RUPU
ASCI
ROAC
LOIN
VIRE
PEPA
FRVI
MACA
ASCO
PYAS
CACA
GABO
EPAN
RITR
TRBO
LODI
BEPA
ACRU
GATR
LAOC
AMAL
VAVI
ELIN
ACMI
RUST
RILA
PYSE
GORE
SYAL
FRVE
EQSY
RIGL
PRPE
BRA SAL
PLE SCH
PLA CUS
NYL SPI
EUR PUL
PTI C-C
PEL RUF
PYL POL
DRE UNC
PTI PUL
CLA CHL
THU REC
HEP SP
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CLA HUL
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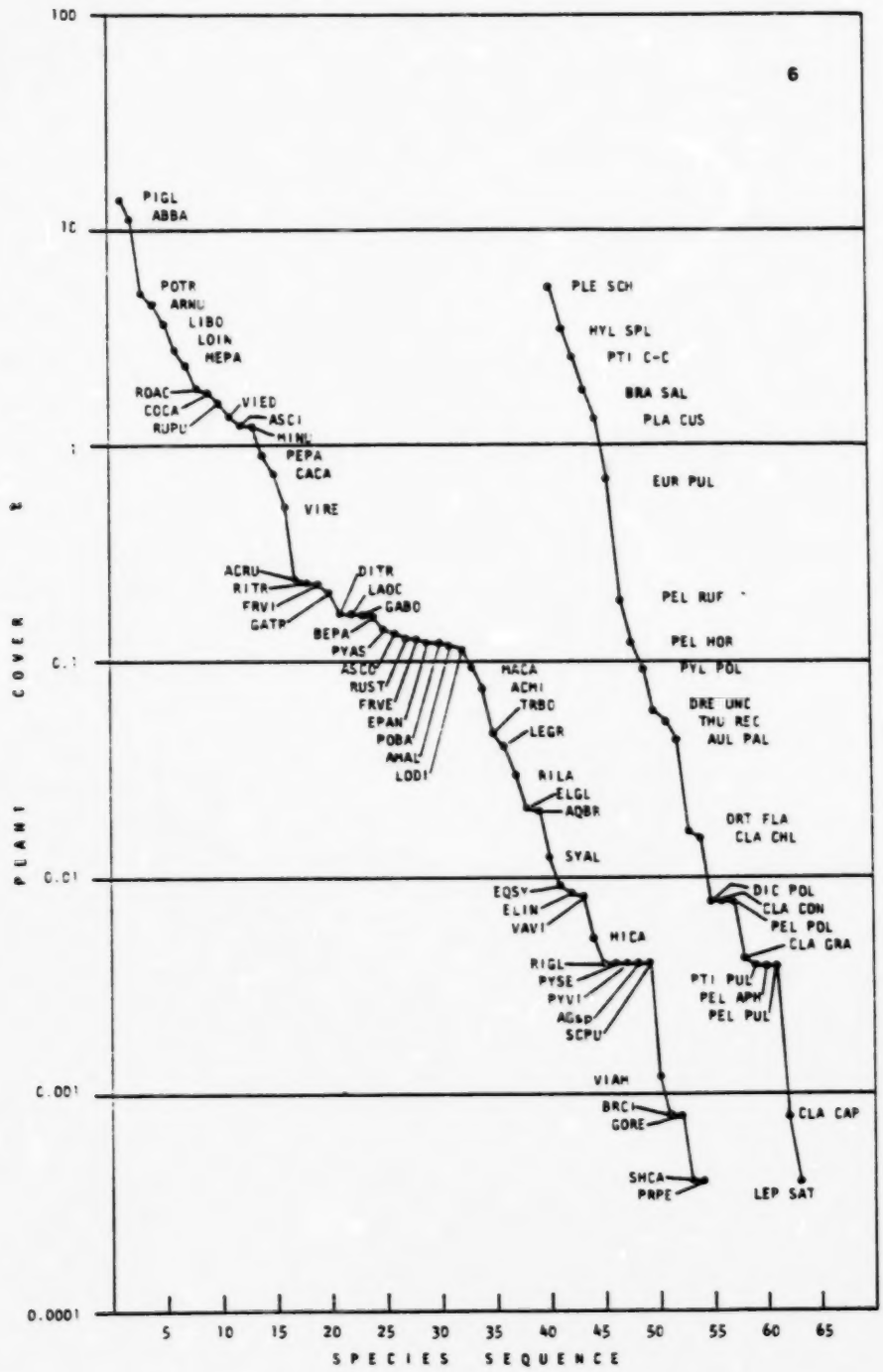
CLA GRA
RHY TRI
CLA CON
PEL APH
PEL POL
5 10 15 20 25 30 35 40 45 50 55 60 65
SPECIES SEQUENCE


6
100
10
1
0.1
0.01
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0.0001
PLANT COVER %
PIGL
ABBA
POTR
ARNU
LIBO
LOIN
MEPA
ROAC
COCA
RUPU
VIED
ASCI
MINU
PEPA
CACA
VIRE
ACRU
RITR
FRVI
GATR
DITR
LAOC
GABO
BEPA
PYAS
ASCO
RUST
FRVE
EPAN
POBA
AMAL
LODI
MACA
ACMI
TRBO
LEGR
RILA
ELGL
AQBR
SYAL
EQSY
ELIN
VAVI
HICA
RIGL
PYSE
PYVI
AGSP
SCPU
VIAM
BRCI
GORE
SHCA
PRPE
PLE SCH
HYL SPL
PTI C-C
BRA SAL
PLA CUS
EUR PUL
PEL RUF
PEL HOR
PYL POL
DRE UNC
THU REC
AUL PAL
ORT FLA
CLA CHL
DIC POL
CLA CON
PEL POL
CLA GRA
PTI PUL
PEL APH
PEL PUL
CLA CAP
LEP SAT
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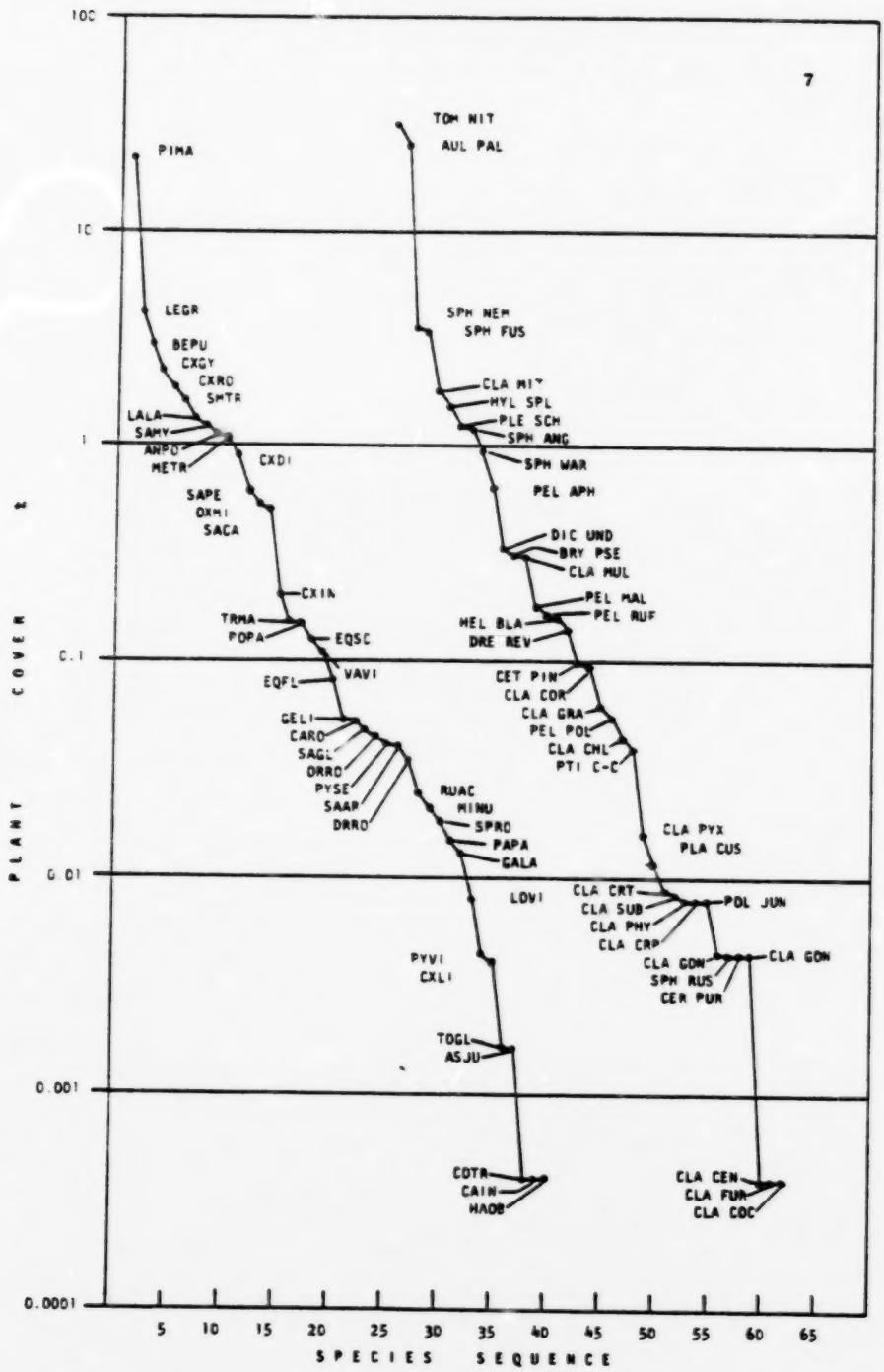
7
TOM NIT
AUL PAL
PIMA
LEGR
BEPU
CXGY
CXRO
SMTR
LALA
SAMY
ANPO
METR
CXDI
SAPE
OXMI
SACA
CXIN
TRMA
POPA
EQSC
EQFL
VAVI
GELI
CARO
SAGL
ORRO
PYSE
SAAP
DRRO
RUAC
MINU
SPRO
PAPA
GALA
LOVI
PYVI
CXLI
TOGL
ASJU
COTR
CAIN
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SPH NEM
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CLA MIT
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SPH WAR
PEL APH
DIC UND
BRY PSE
CLA MUL
PEL MAL
PEL RUF
HEL BLA
DRE REV
CET PIN
CLA COR
CLA GRA
PEL POL
CLA CHL
PTI C-C
CLA PYX
PLA CUS
CLA CRT
CLA SUB
CLA PHY
CLA CRP
POL JUN
CLA GON
CLA GON
SPH RUS
CER PUR
CLA CEN
CLA FUR
CLA COC
100
10
1
0.1
0.01
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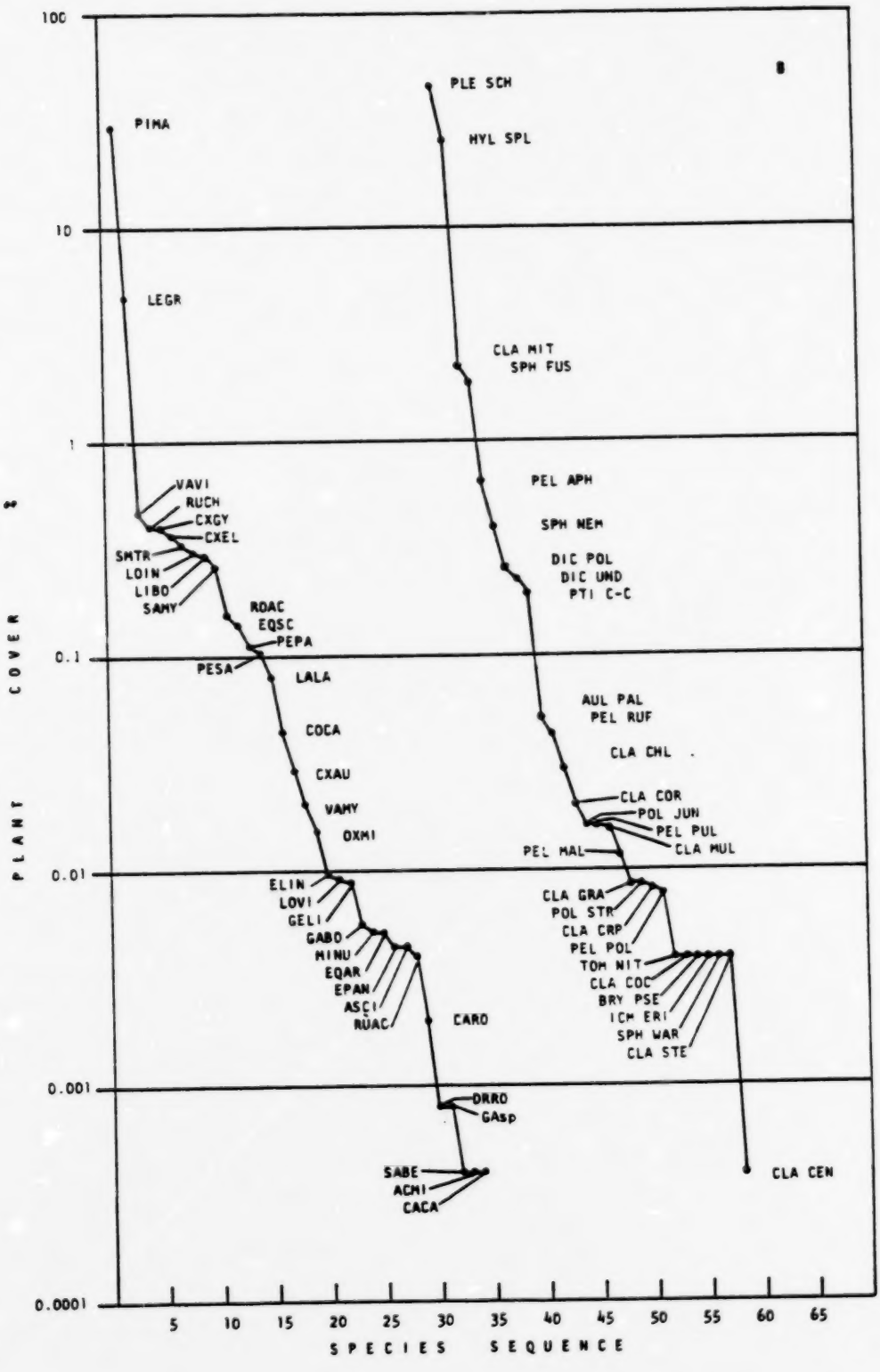
0.0001
PLANT COVER %
5
10
15
20
25
30
35
40
45
50
55
60
65
SPECIES SEQUENCE


100
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PLANT COVER %
PLE SCH
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CXGY
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SAMY
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VAMY
OXMI
AUL PAL
PEL RUF
CLA CHL
CLA COR
POL JUN
PEL PUL
CLA MUL
PEL MAL
ELIN
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MINU
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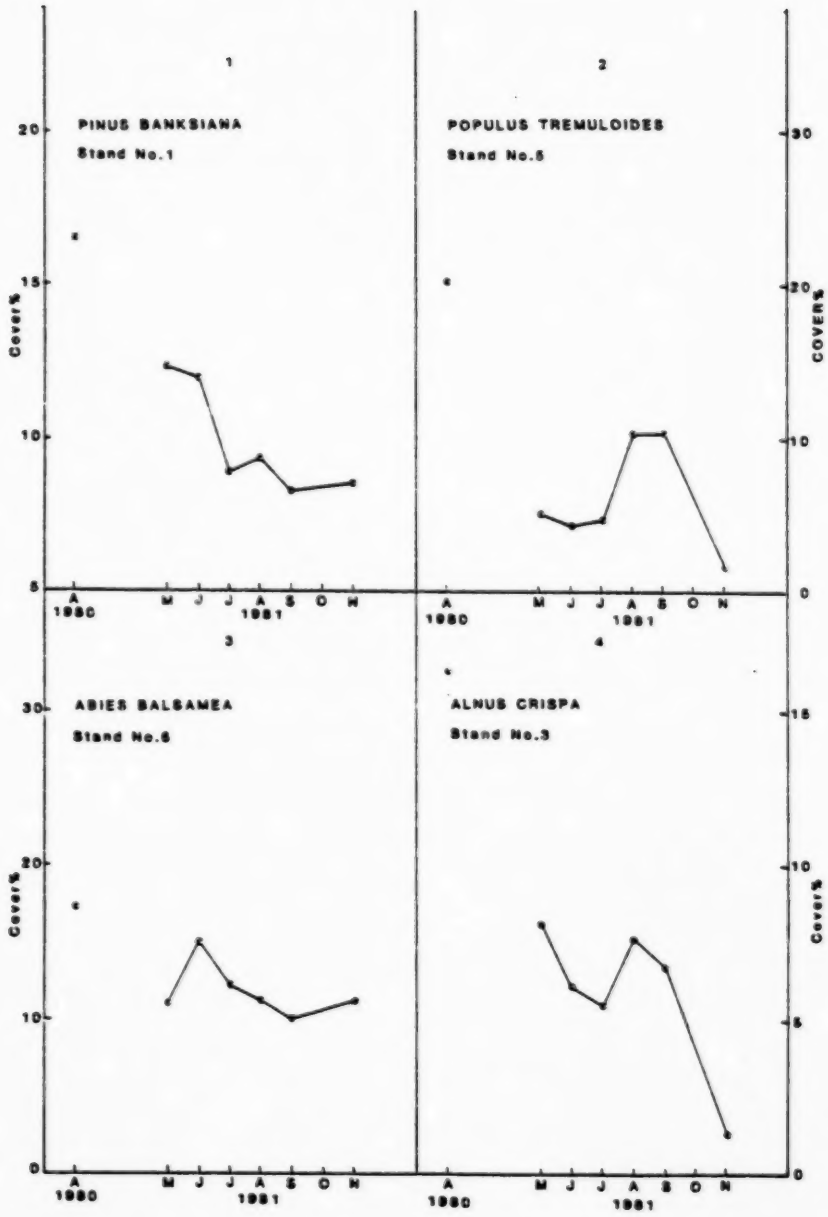
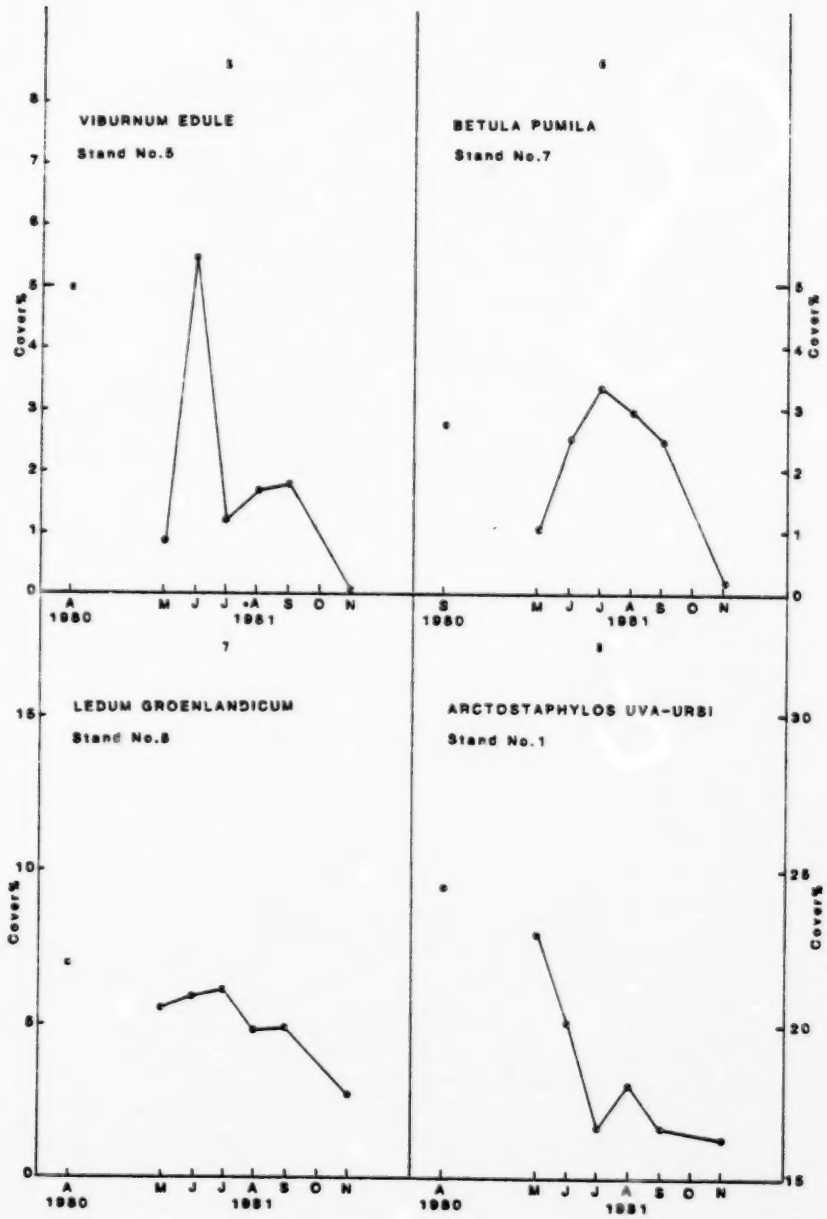
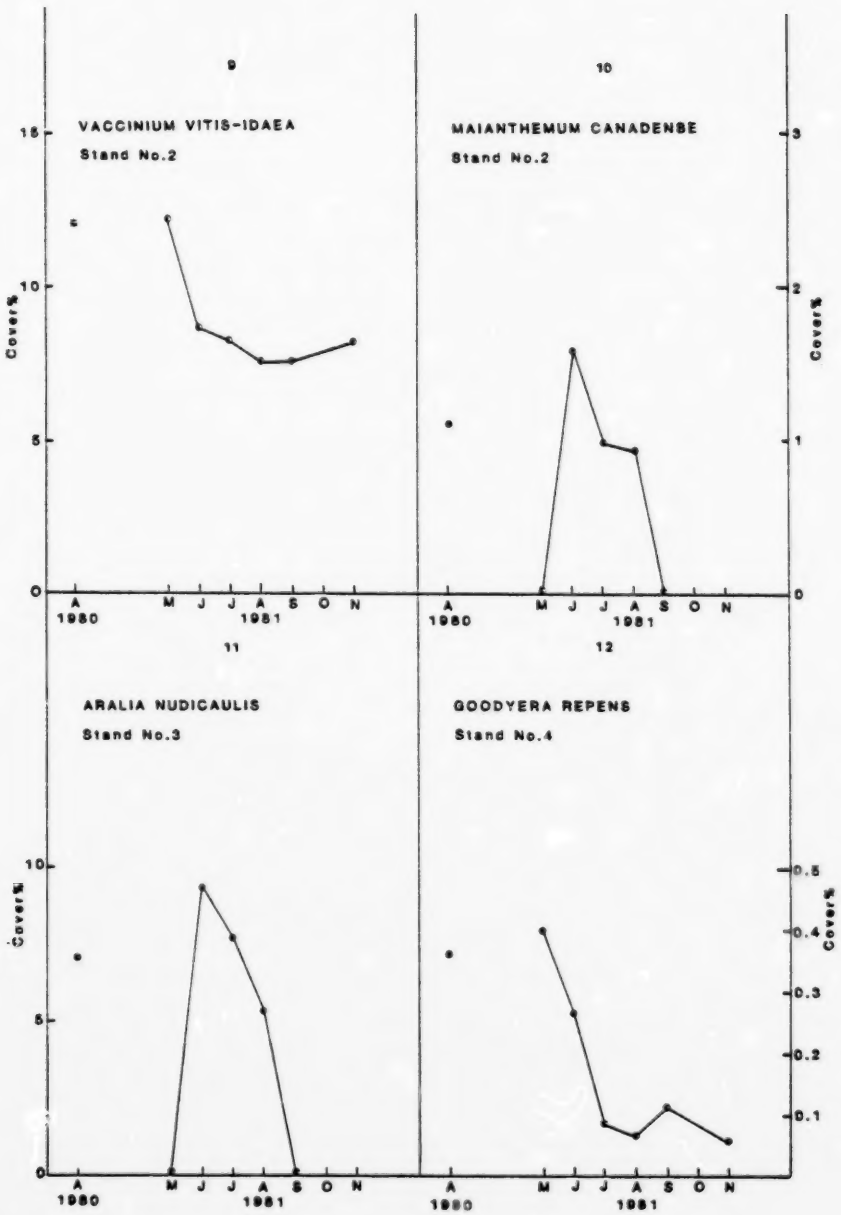
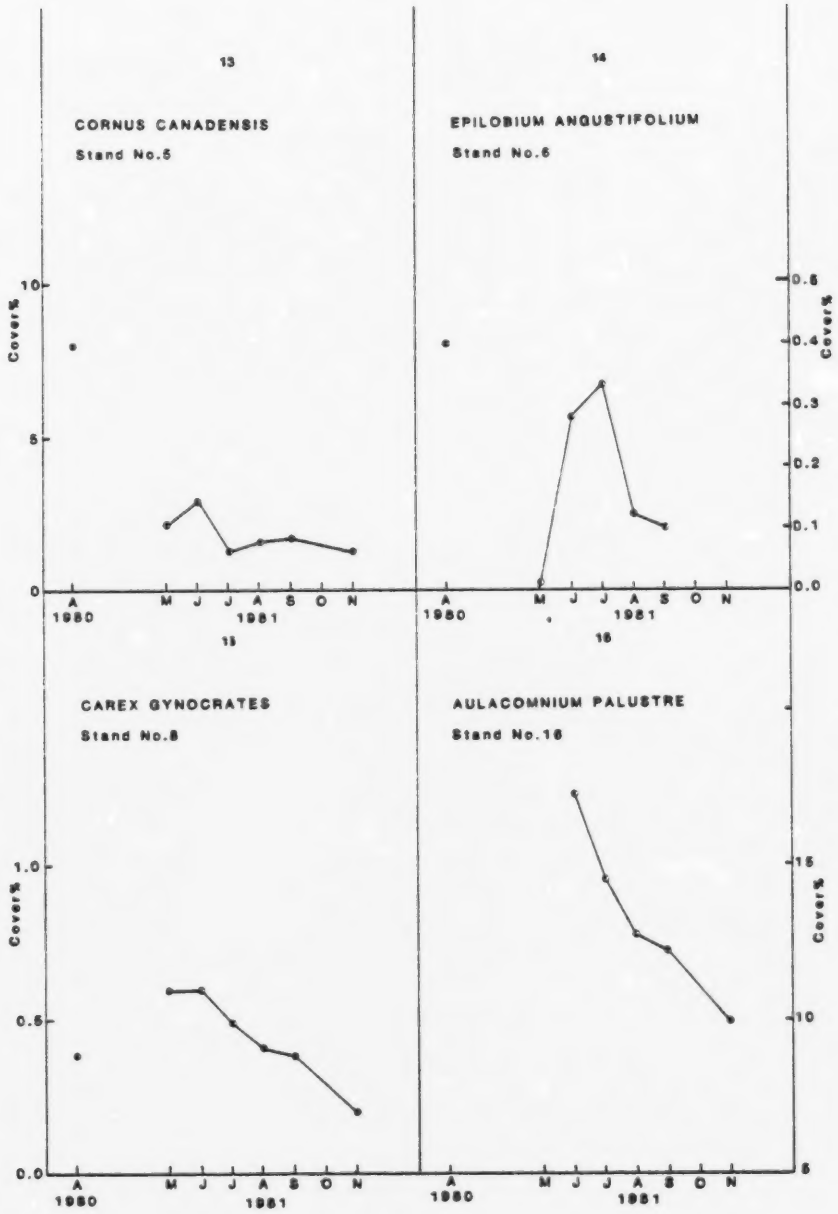
ASCI
RUAC
CARO
CLA GRA
POL STR
CLA CRP
PEL POL
TOM NIT
CLA COC
BRY PSE
ICH ERI
SPH WAR
CLA STE
ORRO
GAsp
SABE
ACMI
CACA
CLA CEN
5
10
15
20
25
30
35
40
45
50
55
60
65
SPECIES SEQUENCE

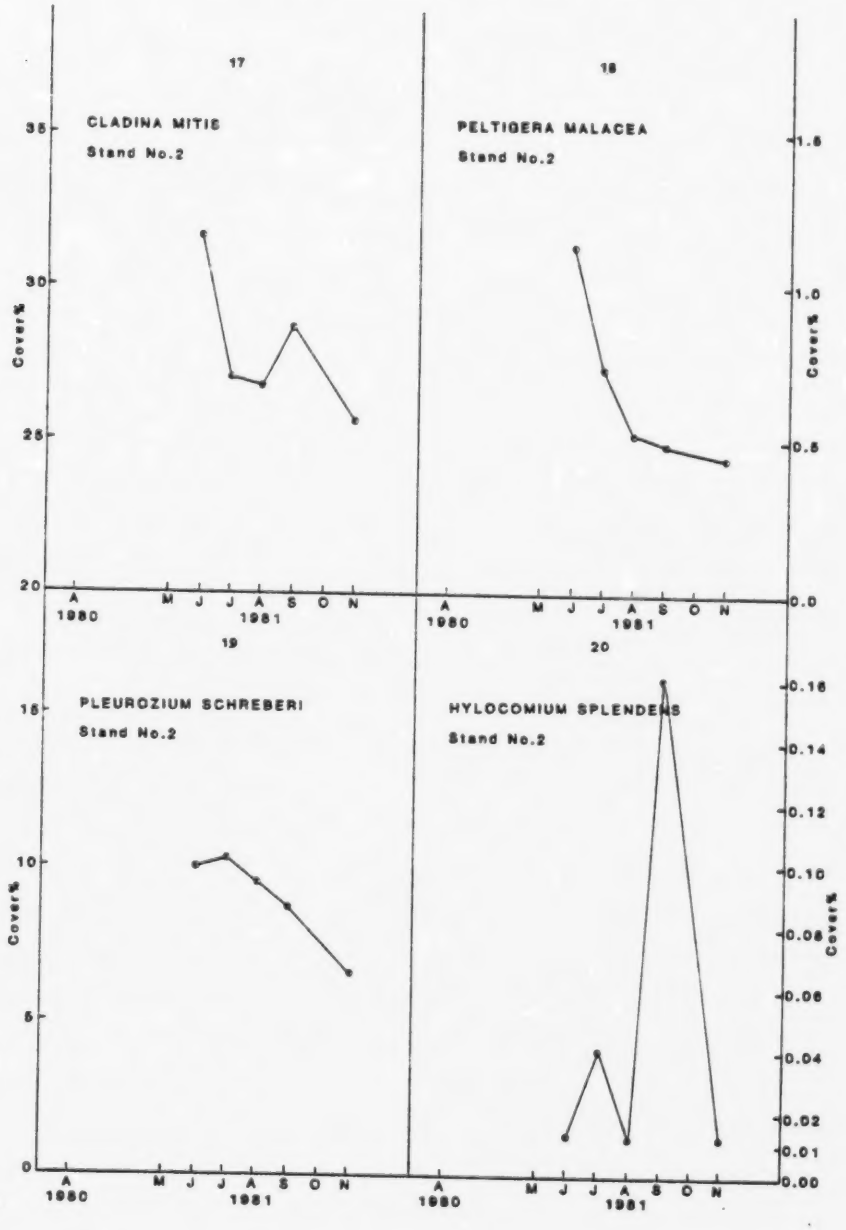
Figure 5. Seasonal and intraseasonal cover dynamics of selected vascular plant, terrestrial bryophyte, and terrestrial lichen species populations in selected SEADYN reference stands in the Hondo - Lesser Slave Lake area of north central Alberta. Vascular species data are from monthly surveys of live shoot cover in 25 5 x 5 m sampling units (see section 3.3.1); bryophyte and lichen species data are from monthly surveys of live thallus cover in 25 71 x 71 cm (0.5 sq m) sampling units (see section 3.3.2). Figure 3 on p 24 gives the locations of sampling units in reference stands.


1
PINUS BANKSIANA
Stand No.1
Cover%
20
15
10
5
A
1980
M J J A S O N
1981
2
POPULUS TREMULOIDES
Stand No.5
COVER%
30
20
10
0
3
ABIES BALSAMEA
Stand No.6
Cover%
30
20
10
0
4
ALNUS CRISPA
Stand No.3
Cover%
15
10
5
0


VIBURNUM EDULE
Stand No.5
BETULA PUMILA
Stand No.7
LEDUM GROENLANDICUM
Stand No.8
ARCTOSTAPHYLOS UVA-URSI
Stand No.1
Cover%
A S O N D J F M A M J J A S O N
1980
1981


9
VACCINIUM VITIS-IDAEA
Stand No.2
Cover%
15
10
5
0
A
1980
M J J A S O N
1981
10
MAIANTHEMUM CANADENSE
Stand No.2
Cover%
3
2
1
0
11
ARALIA NUDICAULIS
Stand No.3
12
GOODYERA REPENS
Stand No.4
0.5
0.4
0.3
0.2
0.1


13
CORNUS CANADENSIS
Stand No.5
Cover%
10
5
0
A
1980
M J J A S O N
1981
14
EPILOBIUM ANGUSTIFOLIUM
Stand No.6
Cover%
0.5
0.4
0.3
0.2
0.1
0.0
15
CAREX GYNOCRATES
Stand No.8
Cover%
1.0
0.5
0.0
16
AULACOMNIUM PALUSTRE
Stand No.16
Cover%
15
10
5


17
CLADINA MITIS
Stand No.2
Cover%
35
30
25
20
A
1980
M J J A S O N
1981
19
18
PELTIGERA MALACEA
Stand No.2
1.5
1.0
0.5
0.0
20
PLEUROZIUM SCHREBERI
Stand No.2
15
10
5
0
HYLOCOMIUM SPLENDENS
Stand No.2
0.16
0.14
0.12
0.10
0.08
0.06
0.04
0.02
0.01
0.00

sampling units and bryoid thallus data from 71 x 71 cm sampling units at monthly intervals (see sections 3.3.1 and 3.3.2). No attempt is made here to assess the significance of differences in the mean values; future contributions will do this.

4.5.1 Vascular Plant Species

Pinus banksiana cover in stand no. 1 declined from 16% in August 1980 to 12% in May and 9% in August 1981 (Figure 5). This decline suggests that shoot cover losses exceeded gains during the 1981 snow-free season. If these losses were due to mortality of needle populations associated with drier than average summer meteorological conditions (see section 4.9.1) and soil moisture stress (see section 4.9.2) then future fluctuations of *P. banksiana* shoot cover may be correlated with these environmental variables. Some needle-rich grouse scats were noted beneath the pines in May of 1981, suggesting that normal mortality due to senescence and shedding may have been augmented by winter grazing activities of upland birds.

Populus tremuloides cover in stand no. 5 was 20% in early August of 1980 but attained a maximum of only 10% in August and September of 1981 (Figure 5). Shortly after leaf enlargement began in May a population of rapidly growing Tent Caterpillars completely defoliated the aspen population, such that *P. tremuloides* cover remained near 5% (mostly woody material) until mid-July when a new population of leaves finally matured. The consequences of this pulse of feeding activity for *P. tremuloides* and the ecosystem as a whole must be significant and will be examined in detail as the project proceeds. Though caterpillars may have been present in 1980 as well, their impact was much less severe, as shown by the August cover of the preferred prey species in the two years.

Abies balsamea cover in stand no. 6 declined from a maximum of 17% in August 1980 to 11% in May and to a minimum of *ca.* 11% in the fall of 1981 (Figure 5). Unlike *Pinus banksiana* in no. 1, *A. balsamea* increased appreciably from May (11%) to June (15%) as the new leaf cohort developed. From June onwards, however, balsam fir

cover declined in the same manner as jack pine cover, possibly for the same reasons (see above). Snowshoe Hares girdle-killed some young fir during the winter of 1980-81 (see slide no. 17, section 7.1).

Alnus crispa cover in stand no. 3 was 16% in August 1980 but attained a maximum of only 8% in May of 1981 (Figure 5). Tent Caterpillars were responsible for much of this contrast, as with *P. tremuloides* in no. 5 (see above), but they did not totally defoliate the green alder population. Assuming that woody above-ground cover of *A. crispa* is *ca.* 2%, then maximum leaf cover of *A. crispa* in 1981 was only about 40% of that in 1980.

Viburnum edule cover in stand no. 5 was 5% in August 1980 but only 1% in August 1981 (Figure 5). After rapidly expanding from 1% in May to 5% cover in June, the *V. edule* population was attacked and defoliated by Tent Caterpillars which had earlier defoliated the *P. tremuloides* canopy above and then migrated down to the understory to satisfy their food requirements. Unlike the aspen and green alder, however, lowbush cranberry did not vigorously produce a second leaf population, though it had three months to do so. The effects of 1981 defoliation on *V. edule* performance in 1982 will be closely followed, as this shrub is normally the dominant understory woody species in mature forests on the *Picea glauca* [*Populus tremuloides*] habitat type.

Betula pumila cover in stand no. 7 was 3% in September 1981 (Figure 5). After experiencing heavy browse by a large and peaking population of Snowshoe Hares during the winter of 1980-81 the bog birch vigorously sprouted new branches in May and June and achieved a maximum cover of 3% in July, after which it steadily declined to a low of 0.2% in November 1981. Heavy browse may occur again during the winter of 1981-82. It will be interesting to see if bog birch can repeat its vigorous recovery behavior of 1981 in 1982.

Ledum groenlandicum cover in stand no. 8 was 7% in August 1980 and 5% in August 1981 and changed very little during the snow-free season (Figure 5). This evergreen, broadleaf shrub is not a preferred browse species of Snowshoe Hare, hence it was not adversely affected during the period of high population density of this herbivore.

The apparent drop in Labrador tea cover from September (5%) to November (3%) 1981 is mostly due, we think, to the winter re-orientation of leaves from almost horizontal to vertical (see Husband 1980), rather than to winter shedding of leaves.

Arctostaphylos uva-ursi cover in stand no. 1 declined slightly from 24% in August 1980 to 23% in May then more rapidly to a low of 16% in November 1981 (Figure 5). This pattern is similar to but even more pronounced than that of *Pinus banksiana* in the same reference stand (see above), and may have occurred for similar reasons, especially soil moisture stress during an unusually dry summer. It is also possible, but less probable, we think and hope, that the monthly survey procedure is having a deleterious impact (trampling-induced mortality) on the bearberry population. If the 1982 snow-free season is both shorter and moister, these alternative hypotheses can be tested. There was virtually no evidence of herbivore use of *A. uva-ursi* in stand no. 1, although fresh Black Bear droppings in no. 2 contained imcompletely digested fruits of bearberry.

Vaccinium vitis-idaea cover in stand no. 2 was 12% in August 1980 and May 1981, then dropped significantly ($P < 0.01$) and stabilized between 8 and 9% for the balance of the snow-free season (Figure 5). This dynamic pattern suggests that the new evergreen leaf cohort did not equal (in density and/or area) the loss of old ones in early summer, in terms of shoot cover. Unlike *A. uva-ursi* in no. 1 (see above), lingonberry seemed to adjust promptly rather than progressively to the summer environment of 1981.

Maianthemum canadense cover in stand no. 2 was 1.1% in August 1980, undetectable in May, reached a peak of 1.6% in June, and vanished again by September 1981 (Figure 5). Its cover in August 1981 (0.9%) was slightly lower than it was in 1980 (1.1%).

Aralia nudicaulis cover in stand no. 3 behaved very similarly to that of *M. canadense* in no. 2 (see above), except that *Aralia* was much more important quantitatively, with a maximum cover of 9% in June 1981 (Figure 5). As with many other vascular species, *A. nudicaulis* cover was lower in August of 1981 (5%) than in August of 1980 (7%). The fact that the *Alnus crispa* canopy above it was

considerably reduced by caterpillars (see above) apparently had little effect on *A. nudicaulis* cover in 1981.

Goodyera repens cover in stand no. 4 was 0.4% in August 1981 and May 1981, then dropped rapidly to a low of *ca.* 0.1% in July where it remained through November (Figure 5). This pattern of behavior closely resembles that of *V. vitis-idaea* in no. 2 (see above), and a similar ecological interpretation is proposed. It is clear that rattlesnake orchid declined greatly during the summer of 1981; since this species is rare, local extinction could begin to occur (e.g., in plot frequency %) if 1982 is equally long and dry.

Cornus canadensis cover in stand no. 5 was 8% in August 1980 but only 2% in August 1981 (Figure 5). Its response curve is very similar to that of the medium shrub, *Viburnum edule,* in the same stand (see above), and probably for the same reason. Tent Caterpillars defoliated much of the population before the leaves had time to enlarge; after the caterpillar pupated, the defoliated *C. canadensis* plants produced dwarf leaves which maintained its cover from 1 to 2% from July through November. Since *C. canadensis* is a wintergreen species, its performance in 1982 will continue to reflect the impact of herbivores in 1981.

Epilobium angustifolium cover in stand no. 6 was 0.4% in August 1980 but only 0.1% in August 1981 (Figure 5). As shown on the response curve, fireweed cover increased rapidly from 0.01% in May to 0.33% in July, then dropped abruptly to 0.1% in August and September, as much of the shoot cover turned from green to yellow and brown (see photo no. 14 in section 7.1). No frosts occurred during this period, but conditions were considerably drier than normal (see section 4.9.1). Though grazed to a minor degree by Tent Caterpillars and other herbivores, the decreased fireweed cover in 1981 cf. 1980 seems mainly attributable to drought-induced mortality of leaf tissue.

Carex gynocrates cover in stand no. 8 was 0.4% in August of 1980 and 1981 (Figure 5). This sedge attained maximum cover in early summer (0.6%) then decreased slowly in cover to a minimum in early November (0.2%) as the tips of the evergreen leaf blades died back faster than the intercalary meristems produced new tissue.

There was little evidence of grazing on this graminoid and moisture seemed plentiful throughout the summer, since the water table was near the ground surface of this black spruce/feather moss forest.

4.5.2 Bryophyte and Lichen Species

The curves showing changing cover of selected bryophytes and lichens (Figure 5) from June through November of 1981 are presented as examples of the results possible with the 25 71 x 71 cm permanent microplots (see 3.3.2). Since the method was not implemented until June, a significant part of the 1981 snow-free season is not available for interpretation. Although the curves are suggestive it is too early to attempt any dependably meaningful interpretation.

'Seeing conditions' and moisture content of thalli are important considerations because some of the bryophytes (e.g., *Polytrichum, Plagiomnium*) have reduced cover and are much less visible when dry. In general, both bryophytes and especially lichens are much more colorful and conspicuous when moist, and their cover is probably greater as well.

The curve for *Aulacomnium palustre* (Figure 5) raises a question awaiting resolution, namely, whether its apparently sharp decline in cover is real or apparent? Young growth in this hygrophilic moss is conspicuously yellow-green in color, gradually darkening through the snow-free season. The possible effect of changing color on cover estimates is not yet known, but it is something to keep in mind, before accepting the hypothesis that the long, dry summer caused a precipitous decrease in the cover of *A. palustre* in reference stand no. 7.

The two principal lichens (*Cladina mitis* and *Peltigera malacea*) and dominant bryophyte (*Pleurozium schreberi*) in stand no. 2 all show a notable decrease in cover from June to November 1981 (Figure 5). On the June, July and August survey dates weather conditions were warm and dry, while the September and November survey dates were cool and damp. Hence the declines in cover shown in Figure 5 cannot be ascribed solely to current moisture conditions

and their effects on the cover and visibility of bryophytes and lichens. It seems far more likely that the summer of 1981 caused a net reduction in cover of many bryoid species, as it did for many vascular species (see 4.5.1 and Figure 5) in the eight reference stands.

4.6 PHENOLOGICAL OBSERVATIONS OF VASCULAR PLANTS IN 1981

Following the plant collection and preservation procedure described in Methods (sections 3.4 and 3.5), 2,625 plants and plant modules (cuttings, branches, etc.) were collected from designated harvest areas adjoining the eight reference stands. Because of the varying abundance of species it was not possible to collect a fixed and constant number of specimens per species during the course of the snow-free season; hence the total number of specimens per species varies greatly.

A variety of phenometric measurements is being made on each of the 2,625 preserved specimens in the laboratory in conjunction with determinations of leaf area, shoot biomass, etc. (see section 4.7 and sample data sheets in section 7.3). These data will be synthesized to produce quantitative accounts of phenodynamic changes in the biomass, leaf area, leaf number, shoot height, inflorescence development, herbivore use, and other attributes of individual plants and plant modules.

A total of six complete phenological cruises of *ca.* 1,200 number-tagged live plants around the perimeters of reference stands was made between late May and late August in 1981, following the procedure outlined in Methods (section 3.4). Such observations are labour-intensive and time-consuming, and the procedure will probably have to be revised and simplified in 1982. Since such a high proportion of plants of most vascular species are sterile (i.e., do not produce flowers or fruits), data on reproductive phenology are often missing or inadequate using the existing procedure. In the future it may be necessary to (1) stratify the sample of number-tagged plants such that fertile as well as sterile individuals are deliberately included, or (2) assess the reproductive phenophases in the species

populations by more subjective scanning of more plants, perhaps from fixed observation points.

4.7 ABOVE-GROUND BIOMASS, LEAF AREA AND SHOOT COVER RELATIONSHIPS OF *EPILOBIUM ANGUSTIFOLIUM* IN 1981

Using the methods described in section 3.5, the results obtained for *Epilobium angustifolium* (fireweed) are presented in Figure 6. A total of 32 specimens were collected from reference stand nos. 1, 2, 3, 5 and 6, starting on 14 May, shortly after shoot emergence began, and ending on 25 August 1981, when plants were rapidly senescing (see section 4.5.1).

Data-points in the three scatter diagrams indicate simple, linear relationships between specimen biomass, leaf area and shoot cover for *E. angustifolium*. The squared regression coefficients (r^2) of the six linear regression equations range from 0.83 to 0.90, indicating very close linkage between the three attributes. Hence it is possible to estimate, with good accuracy, shoot biomass and leaf area of fireweed populations from the shoot cover estimates made at monthly intervals in the reference stands.

Table 8 gives the estimated live shoot biomass and leaf area of *Epilobium angustifolium* on seven monthly survey dates in reference stand no. 6 (see also Figure 5), based on allometric estimation from mean % shoot cover, i.e., the two appropriate regression equations in Figure 6. Shoot biomass was 0.15 kg ha^{-1} on 11 May, rose to a peak value of 4.12 on 13 July, dropped sharply to 1.50 on 17 August, after which it declined slowly to 1.24 on 23 September and nil on 4 November 1981. Leaf area of *E. angustifolium* (expressed as one surface only) is slightly more than 2X shoot cover; hence maximum leaf area in stand no. 6 on 13 July 1981 was 72 m^2 ha^{-1}, not insignificant in terms of either photosynthesis or food for herbivores. Estimated leaf area reduction by grazing insects in 1981 was *ca.* 8% of the original, i.e., pre-grazed leaf area, based on measurements of missing portions of leaf blades on specimens collected in July and August 1981.

Figure 6. Scatter diagrams with regression equations and lines for live shoot cover, shoot biomass, and leaf area of *Epilobium angustifolium* (fireweed) in the Hondo - Lesser Slave Lake area of north central Alberta. See sections 3.5.1 and 4.7 for details.

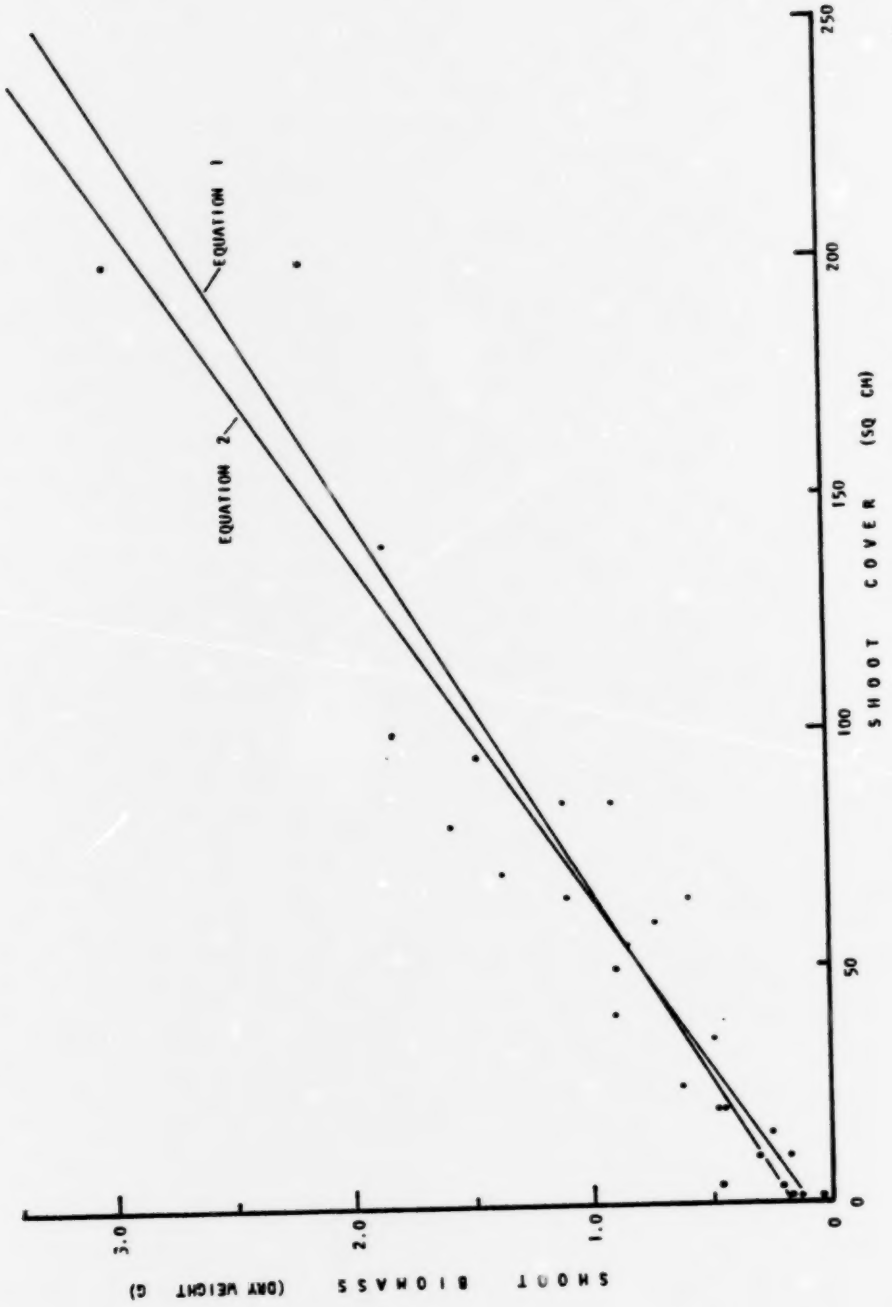
Equation 1.	$SB = 0.1757 + 0.0124\ SC$	$r^2 = 0.90$
2.	$SC = -7.166 + 72.569\ SB$	$r^2 = 0.90$
3.	$LA = 5.2361 + 2.1674\ SC$	$r^2 = 0.86$
4.	$SC = 5.9009 + 0.3968\ LA$	$r^2 = 0.86$
5.	$SB = 0.1980 + 0.0052\ LA$	$r^2 = 0.83$
6.	$LA = -12.66 + 159.84\ SB$	$r^2 = 0.83$

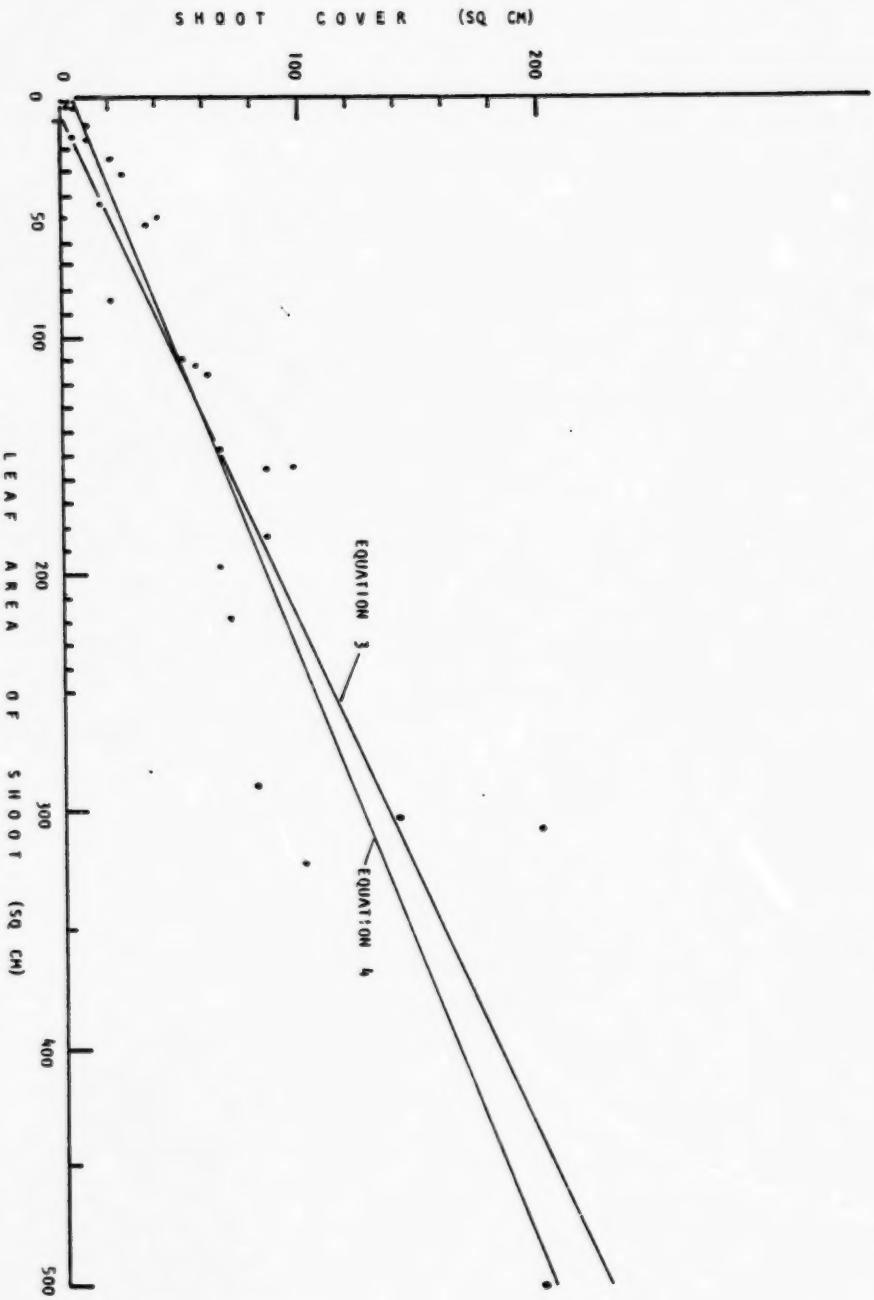
where, *SB* is live shoot biomass expressed as oven-dry weight (65°C) in grams.

SC is live shoot cover expressed as the vertical projection in sq cm.

LA is live leaf area of the shoot expressed as the sum of the measured areas of its leaves in sq cm (one surface only).

r^2 is the square of the regression coefficient.


EQUATION 1
EQUATION 2
SHOOT BIOMASS (DRY WEIGHT G)
SHOOT COVER (SQ CM)
0
1.0
2.0
3.0
50
100
150
200
250


SHOOT COVER (SQ CM)
0
100
200
LEAF AREA OF SHOOT (SQ CM)
0
50
100
200
300
400
500
EQUATION 3
EQUATION 4

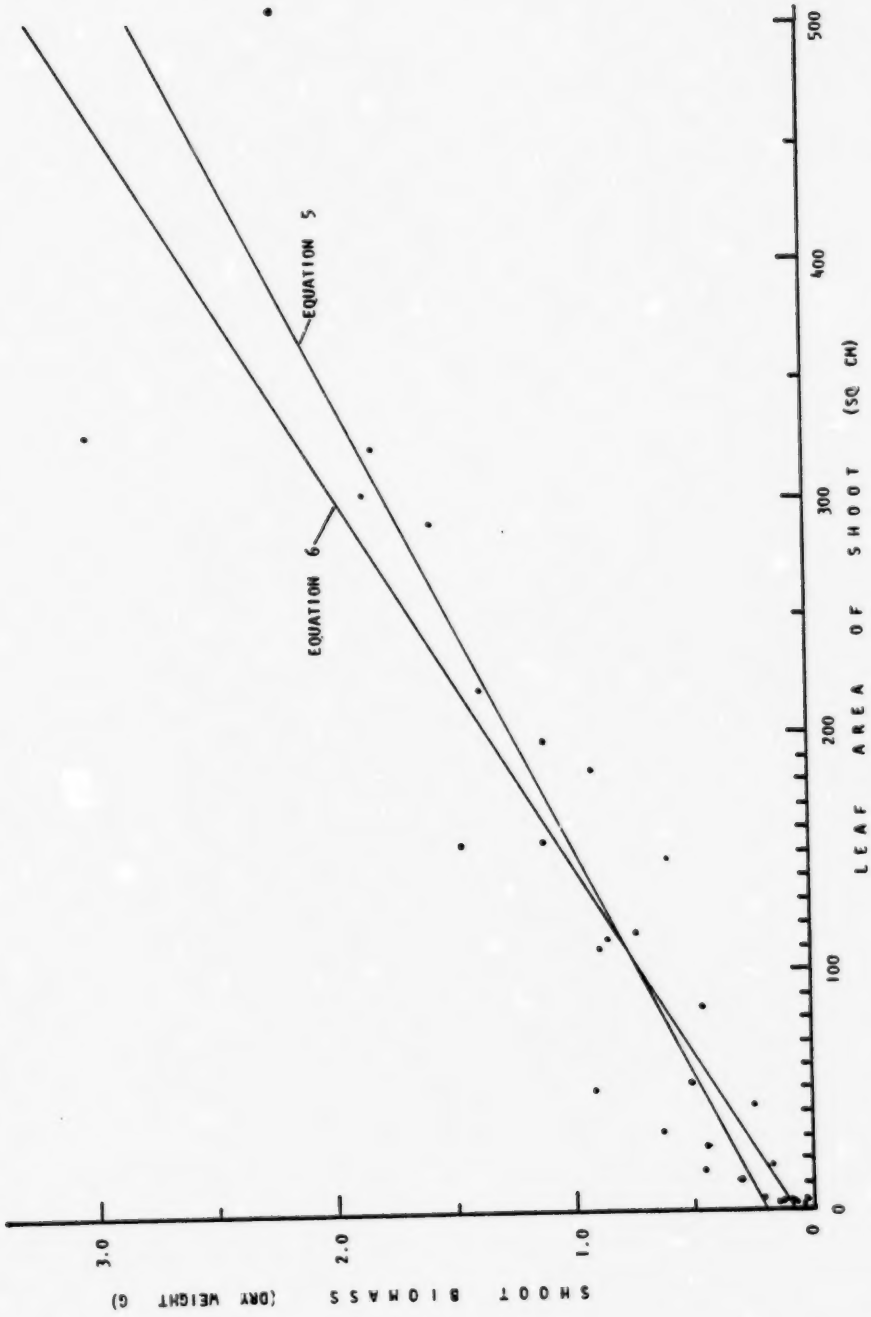

EQUATION 5
EQUATION 6
SHOOT BIOMASS (DRY WEIGHT G)
LEAF AREA OF SHOOT (SQ CM)
0
1.0
2.0
3.0
100
200
300
400
500

Table 8. Estimated live shoot biomass and leaf area of *Epilobium angustifolium* population in reference stand no. 6 in August of 1980 and during the snow-free season of 1981. Based on allometric estimates from mean % shoot cover data and the regression equations in Figure 6.

Survey Date	Shoot Cover		Shoot Biomass	Leaf Area[a]
	%	$m^2\ ha^{-1}$	$kg\ ha^{-1}$	$m^2\ ha^{-1}$
1980				
11 August	0.40	40	4.96	86.7
1981				
11 May	0.012	1.2	0.15	2.6
12 June	0.28	28	3.47	60.7
13 July	0.33	33	4.12	72.0
17 August	0.12	12	1.50	26.2
23 September	0.10	10	1.24	21.7
4 November	0.00	0	0.00	0.0

[a] Leaf area expressed as one surface only.

A new sample of specimens of *E. angustifolium* will be collected and analyzed in 1982 to determine if the allometric relationships evinced in 1981 are valid, as well as to test hypothesis no. 9 and achieve objective nos. 1, 2, 3, and 4 (see Introduction section 1.3) for this forb species.

Similar regression equations and estimations of shoot biomass and leaf area are being prepared for all other understory vascular species recorded in the eight reference stands. As of the date of this report *ca.* 1,750 specimens from the total 1981 collection of 2,625 specimens had been measured for leaf area. Oven-dry (65°C) weight determinations are much less time-consuming. Much of the 1981-82 winter laboratory work of this project was devoted to 'shoot analysis', i.e., leaf area and shoot biomass measurements.

4.8 POPULATION STRUCTURE OF TREE SPECIES

Tree species populations in reference stand nos. 3 and 4 and in 90 of the 100 sampling units of stand no. 5 were inventoried according to the procedure described in Methods (section 3.6) during the 1981 field season. Stem maps have not been produced for these three stands yet.

Table 9 gives the population size-structures of four tree species in reference stand no. 5, expressed as the number of living, dead-standing, and dead-down stems >2 cm dbh in 2 cm dbh-classes in late July 1981. The two co-dominant trees, *Picea glauca* and *Populus tremuloides*, have sharply contrasting population size-structures. *Picea glauca* has nearly twice the living density of *P. tremuloides* and many fewer dead stems. The *P. tremuloides* population contains many more stems in the larger dbh-classes and no doubt has much more living above-ground biomass than the *P. glauca* population. This population pattern supports the prediction that *P. glauca* will gradually succeed *P. tremuloides*, in the absence of major disturbance, and thus the plant community in stand no. 5 will increasingly resemble that in stand no. 6, which lies *ca.* 100 m north of it across a burn margin.

Table 9. Population size-structures of four tree species in SEADYN reference stand no. 5 in late July 1981. Expressed as number of stems >2 cm dbh[a] by 2 cm dbh-classes in 90 of the 100 sampling units, i.e., 0.225 ha.

DBH-Class[a] (cm)	Species											
	Picea glauca			*Populus tremuloides*			*Populus balsamifera*			*Betula papyrifera*		
	L[b]	DS	DD	L	DS	DD	L	DS	DD	L	DS	DD
2-4	56	33	1	2	2	.	.	.	.	.	.	.
4-6	102	8	.	2	13	5	.	.	.	.	.	.
6-8	65	2	1	3	9	18	.	1	1	2	.	.
8-10	77	.	.	6	15	24	.	2	1	2	2	1
10-12	68	1	.	14	10	31	.	3	2	1	1	.
12-14	55	.	.	23	14	15	3	2	1	.	.	.
14-16	32	.	.	37	3	6	1	.	.	.	.	.
16-18	16	.	.	45	3	2	1	.	.	.	.	.
18-20	4	.	.	43	.	.	2	.	.	.	.	.
20-22	1	.	.	34	.	.	.	.	.	.	.	.
22-24	.	.	.	17	.	.	.	.	.	.	.	.
24-26	.	.	.	10	.	.	1	.	.	.	.	.
26-28	.	.	.	5	.	.	.	.	.	.	.	.
28-30	.	.	.	4	.	.	.	.	.	.	.	.
30-32	.	.	.	2	.	.	.	.	.	.	.	.
32-34	.	.	.	2	.	.	.	.	.	.	.	.
34-36	.	.	.	.	.	.	.	.	.	.	.	.
Total	476	44	2	249	69	101	8	8	5	5	3	1
ha^{-1}	2116	196	9	1107	307	449	36	36	22	22	13	4

[a] dbh = diameter of trunk 1.5 m above ground.

[b] L = living; DS = dead standing; DD = dead down.

The aluminum number tags used to identify trees were loosely nailed (zinc-coated nails) to trees >5 cm dbh and wired to branches of trees from 2 to 5 cm dbh, in order to minimize injury to the smaller trees. Number tags were firmly nailed to dead-down trees; hence trees falling after the inventory will be easier to recognize and record.

Stem-mapping is a labour-intensive and time-consuming process that causes a certain amount of unavoidable disturbance to the reference stands. Future observations of both tree population and other attributes of reference stands, however, can be made much more efficiently and precisely with the assistance of stem map data. For example, we intend to measure annual radial increment in a representative range of dbh-classes for each tree species in each reference stand each winter, using the same randomly chosen sample of number-tagged trees. Noteworthy events in reference stands (e.g., locations of dead Snowshoe Hares) can be easily positioned and re-located by measuring distances to surrounding number-tagged trees.

4.9 ENVIRONMENTAL MEASUREMENTS IN 1981

Section 3.7 in Methods details the environmental measurements made in and around the eight reference stands in 1981 and gives the observation periods for each type of measurement.

4.9.1 Atmospheric Component

Table 10 gives daily air temperature data from the Hondo and NW stations of the study area for the period 6 May to 25 October 1981. Hondo is located in a topoclimatically cooler area than NW, so its temperatures tend to be slightly lower. Minimum and maximum temperature data from reference stands do not radically depart from those at the recording stations, so the following account seems reasonable for the study area as a whole for the period of observation.

Table 10. Daily air temperature data from the Hondo and NW stations of the SEADYN study area for the period 6 May to 25 October 1981. Data are from calibrated Lambrecht thermo-hygrographs mounted 1.5 m above ground in standard Stevenson screens; temperatures are °C.

HONDO STATION (55°4' N Lat 114°2'30" W Long)

Month / Day	Min	Max	Mean	Month / Day	Min	Max	Mean	Month / Day	Min	Max	Mean
May				June				July			
1	M[a]	M	M	1	3	21	12	1	4	16	10
2	M	M	M	2	7	23	15	2	1	21	11
3	M	M	M	3	7	17	12	3	3	23	13
4	M	M	M	4	0	16	8	4	7	28	18
5	M	M	M	5	0	M	M	5	0	23	12
6	M	13	M	6	M	M	M	6	8	21	15
7	3	17	10	7	4	13	9	7	8	9	9
8	-3	10	4	8	2	16	9	8	5	17	11
9	0	8	4	9	-4	18	7	9	3	19	11
10	-6	15	5	10	-4	15	6	10	-1	21	10
11	-6	19	7	11	0	16	8	11	5	20	13
12	-5	21	8	12	0	17	9	12	2	27	15
13	-3	23	10	13	4	15	10	13	6	26	16
14	1	13	7	14	3	18	11	14	11	21	16
15	-2	14	6	15	-2	20	9	15	11	20	16
16	-2	18	8	16	3	18	11	16	5	21	13
17	7	19	13	17	0	6	3	17	4	24	14
18	4	20	12	18	3	11	7	18	5	28	17
19	-2	24	11	19	-3	13	5	19	7	30	19
20	5	25	15	20	-4	14	5	20	11	21	16
21	1	23	12	21	0	16	8	21	9	20	15
22	0	23	12	22	4	11	8	22	9	19	14
23	10	21	16	23	4	16	10	23	9	18	14
24	10	24	17	24	-3	16	7	24	2	17	10
25	6	25	16	25	3	18	11	25	0	19	10
26	6	17	12	26	-1	22	11	26	2	20	11
27	-2	21	10	27	6	17	12	27	7	24	16
28	6	20	13	28	-2	16	7	28	10	19	15
29	-1	21	10	29	-1	19	9	29	8	17	13
30	2	20	11	30	3	22	13	30	3	20	12
31	6	12	9					31	2	20	11
$\bar{x}$	1.4	18.7	10.1	$\bar{x}$	1.1	16.4	8.8	$\bar{x}$	5.4	20.0	13.2

continued ...

Table 10. Continued

HONDO STATION (Concluded)

Month Day	Min	Max	Mean	Month Day	Min	Max	Mean	Month Day	Min	Max	Mean
August				September				October			
1	4	21	13	1	3	15	9	1	3	8	6
2	3	21	12	2	0	7	4	2	-2	8	3
3	M	24	M	3	-7	12	3	3	-8	6	-1
4	4	24	14	4	2	15	9	4	-12	7	-3
5	3	27	15	5	0	16	8	5	-7	10	-2
6	6	26	16	6	1	18	10	6	-6	10	2
7	5	27	16	7	1	24	13	7	0	9	5
8	4	29	17	8	0	27	14	8	-3	0	-1
9	5	29	17	9	-1	29	14	9	-4	-2	-3
10	5	31	18	10	9	18	14	10	-5	-1	-3
11	2	26	14	11	0	17	9	11	-7	-1	-4
12	10	20	15	12	-1	8	4	12	-4	3	0
13	-2	20	9	13	-6	13	4	13	-8	5	1
14	0	5	13	14	-8	15	4	14	-7	13	3
15	4	28	16	15	-5	20	8	15	-4	14	5
16	0	27	14	16	-2	22	10	16	4	9	7
17	5	27	16	17	-2	27	13	17	-8	8	0
18	0	23	12	18	3	22	13	18	-7	14	4
19	4	27	16	19	-1	15	7	19	-8	4	-2
20	8	14	11	20	2	9	6	20	-9	-3	-6
21	5	23	14	21	-8	13	25	21	-11	-3	-7
22	4	25	15	22	-3	11	4	22	-20	-3	-12
23	2	26	14	23	0	8	4	23	-6	5	0
24	10	25	18	24	-7	M	M	24	-7	-3	-2
25	9	25	17	25	-4	9	3	25	-7	-3	-5
26	12	28	20	26	-7	11	2	26	M	M	M
27	15	23	19	27	-7	8	1	27	M	M	M
28	3	21	12	28	-1	10	5	28	M	M	M
29	8	10	9	29	-5	11	3	29	M	M	M
30	1	7	4	30	-9	13	2	30	M	M	M
31	3	14	9					31	M	M	M
$\bar{X}$	4.7	23.3	14.0	$\bar{X}$	-2.1	15.3	7.0	$\bar{X}$	-6.0	4.6	-1.0

continued ...

Table 10. Continued

NW STATION (55°10'30" N Lat 114°19'20" W Long)

Month/Day	Min	Max	Mean	Month/Day	Min	Max	Mean	Month/Day	Min	Max	Mean
May				June				July			
1	M	M	M	1	3	21	12	1	1	22	12
2	M	M	M	2	3	23	13	2	2	26	14
3	M	M	M	3	7	19	13	3	9	28	19
4	M	M	M	4	2	17	10	4	7	22	15
5	M	M	M	5	5	22	14	5	1	M	M
6	M	M	M	6	3	12	8	6	M	M	M
7	4	18	11	7	M	M	M	7	M	M	M
8	-3	12	5	8	-3	18	9	8	M	M	M
9	0	8	4	9	-1	18	9	9	M	M	M
10	-6	15	5	10	2	18	10	10	M	M	M
11	-4	19	8	11	1	17	9	11	M	M	M
12	-4	21	9	12	6	16	11	12	M	M	M
13	-3	23	10	13	6	19	13	13	M	28	M
14	2	13	6	14	1	22	12	14	12	21	17
15	-2	14	6	15	5	19	12	15	12	19	16
16	-4	17	7	16	2	7	5	16	8	23	16
17	6	19	7	17	5	13	9	17	5	25	15
18	3	20	9	18	-2	15	7	18	7	29	18
19	-1	24	12	19	-3	14	6	19	8	29	19
20	4	24	14	20	0	17	9	20	11	21	16
21	2	23	13	21	6	12	9	21	12	18	15
22	1	23	12	22	4	18	11	22	10	15	13
23	7	20	14	23	0	18	9	23	11	19	15
24	9	24	17	24	4	19	12	24	4	18	11
25	3	24	14	25	0	23	12	25	0	20	10
26	3	17	10	26	8	18	13	26	4	21	13
27	-1	20	10	27	0	18	9	27	8	24	16
28	6	19	13	28	1	20	11	28	10	21	16
29	2	20	11	29	4	24	14	29	9	18	14
30	0	19	10	30	9	17	13	30	2	21	12
31	7	13	10					31	3	21	12
$\bar{x}$	1.9	18.8	10.4	$\bar{x}$	2.8	17.7	10.3	$\bar{x}$	6.8	22.1	14.5

continued ...

Table 10. Concluded

NW STATION (Concluded)

Month Day	Min	Max	Mean
August			
1	4	22	13
2	4	22	13
3	4	24	14
4	6	26	16
5	6	27	17
6	9	27	18
7	8	28	18
8	6	30	18
9	7	30	19
10	7	31	19
11	6	27	17
12	10	25	18
13	1	20	11
14	2	26	14
15	5	28	17
16	3	26	15
17	5	26	16
18	6	24	15
19	5	27	16
20	10	17	14
21	6	24	15
22	4	26	15
23	4	27	16
24	6	26	16
25	8	25	17
26	11	28	20
27	10	M	M
28	6	22	14
29	8	11	10
30	3	9	6
31	4	14	9
$\bar{X}$	5.9	24.2	15.1

Month Day	Min	Max	Mean
September			
1	4	16	10
2	1	8	5
3	-5	14	5
4	3	16	10
5	1	17	9
6	1	19	10
7	2	26	14
8	3	27	15
9	2	29	16
10	11	19	15
11	4	18	11
12	4	15	10
13	-5	15	5
14	-6	16	5
15	-3	21	9
16	-1	22	11
17	1	29	15
18	5	22	14
19	3	17	10
20	4	11	8
21	-5	14	5
22	-2	12	5
23	M	11	M
24	-3	7	2
25	-4	11	4
26	-5	12	4
27	-7	10	2
28	-4	10	3
29	-3	11	4
30	-7	13	3
$\bar{X}$	-0.4	16.3	8.0

Month Day	Min	Max	Mean
October			
1	2	8	5
2	-4	9	3
3	-6	5	-1
4	-8	6	-1
5	-7	10	2
6	-6	9	2
7	-3	8	3
8	0	2	1
9	-3	-1	-2
10	-4	0	-2
11	-5	-1	-3
12	-3	5	1
13	-6	6	0
14	-5	15	5
15	-3	15	6
16	4	10	7
17	-5	9	-2
18	-6	15	5
19	-4	4	0
20	-9	-2	-6
21	-9	-2	-6
22	-18	-3	-11
23	-6	5	-1
24	-6	M	M
25	M	M	M
26	M	M	M
27	M	M	M
28	M	M	M
29	M	M	M
30	M	M	M
31	M	M	M
$\bar{X}$	-5.1	5.7	0.3

[a] M = data missing.

Compared with the 30-year temperature normals at Slave Lake (Environment Canada 1975; see Figure 2, p 19), 1981 mean daily temperatures in the study area were as follows:

	Slave Lake (1941-1970)	Hondo (1981)	NW (1981)
May	9.1	10.1	10.4
Jun	13.1	8.8	10.3
Jul	15.7	13.2	14.5
Aug	14.1	14.0	15.1
Sep	9.2	7.0	8.0
Oct	3.4	-1.0	0.3

May was slightly warmer than average (but note first six days of data missing); June and October were about 3°C cooler than average; July and September were slightly cooler than average; and August was very close to average. Both June and September in the study area had more days with frost than is normal at Slave Lake. Overall, then, the 1981 snow-free season in the study area was cooler than the long-term average at Slave Lake.

Table 11 gives daily precipitation amounts at the Hondo station for the period 7 May to 28 August 1981. Although precipitation data from the other stations have not been completely processed as of the date of this report, a few comments can be made. There was considerable variation among stations in terms of amounts received from light showers and localized thunderstorms, but very little variation among stations in terms of amounts received from general, heavier rains.

Compared with the 30-year precipitation normals at Slave Lake (Environment Canada 1975; see Figure 2, p 19) summer precipitation in the study area was as follows:

	Slave Lake (1941-1970)	Hondo (1981)
May	45.2 mm	9.1 mm
Jun	67.8	74.9
Jul	79.5	120.3
Aug	65.5	9.8
Summer	258.0	214.0

Table 11. Daily precipitation data from the Hondo Station of the SEADYN study area for the period 7 May to 28 August 1981. Data are from a 15 cm diameter receiver mounted 0.5 m above ground, measured in mm each morning.

May		June		July		August	
1	M[a]	1	5.4	1	6.8	1	5.6
2	M	2	-	2	T	2	T
3	M	3	4.2	3	T	3	T
4	M	4	3.8	4	1.6	4	1.2
5	M	5	T	5	T	5	T
6	M	6	-	6	-	6	T
7	0.2	7	7.3	7	12.6	7	T
8	-[b]	8	T	8	12.5	8	T
9	-	9	1.1	9	0.1	9	T
10	T[c]	10	0.4	10	T	10	-
11	T	11	T	11	-	11	-
12	T	12	1.6	12	0.3	12	-
13	T	13	2.6	13	T	13	-
14	-	14	1.4	14	T	14	-
15	-	15	-	15	0.2	15	-
16	-	16	0.2	16	-	16	0.8
17	-	17	28.6	17	8.8	17	T
18	T	18	1.4	18	T	18	T
19	T	19	T	19	T	19	-
20	T	20	0.2	20	0.6	20	-
21	T	21	5.2	21	11.0	21	2.1
22	T	22	3.7	22	49.2	22	0.1
23	-	23	7.4	23	12.5	23	T
24	T	24	-	24	1.0	24	-
25	-	25	T	25	T	25	T
26	-	26	0.4	26	T	26	T
27	0.3	27	T	27	T	27	-
28	T	28	T	28	3.0	28	T
29	T	29	T	29	T	29	M
30	4.4	30	T	30	T	30	M
31	4.2			31	T	31	M
		Σ	74.9				
Σ	9.1			Σ	120.3	Σ	9.8

[a] M = missing data.

[b] - = no precipitation

[c] T = trace only; often caused by dew or melted frost.

May and August were much drier than average; July was much wetter than average; and June was slightly wetter than average. The two largest daily totals occurred on 22 July (49.2 mm) and 17 June (28.6 mm). Hence the four-month summer of 1981 in the study area was considerably drier than average overall, very dry at the beginning and end, and much wetter than average in the middle.

Other atmospheric environment variables were measured during the summer of 1981 (see section 3.7.1) and these data are available on request from the authors.

4.9.2 Soil Component

Soil moisture and temperature readings were made from Coleman sensors at mid-horizon positions in soil profiles monitored at the SW and NE corners in each of the eight reference stands (see section 3.7.2). Although the sensors were inserted carefully to minimize disturbance to the soil profile, it is doubtful if root re-growth and stabilization occurred around them until late summer. Conversion of soil resistance data to soil water potential data cannot be accomplished until moisture retention curves are generated for samples taken from the profiles; this laboratory work is currently being done by Wayne Strong. The results will appear in future project reports.

4.10 PHOTOGRAPHIC DOCUMENTATION

An annotated set of 60 color slides is included in the Appendix (Section 7.2) of the original set of reports. These photographs were taken according to methods described in section 3.8 and are intended to provide representative documentation of (1) plant communities and habitats during the 1981 snow-free season in the eight reference stands, from a variety of vantage points (n = 40); (2) time-lapse changes in the structure and development of terrestrial bryophyte and lichen communities, from fixed tripod positions (n = 10); (3) field work in progress, the Hondo Research Laboratory facilities, etc. (n = 10).

The slide annotations (section 7.1) are very brief, ecologically oriented, and intended to complement the text of this report.

A SEADYN slide collection is maintained in the Plant Ecology Section, Department of Botany, University of Alberta. It is available for viewing and duplication on request from the authors.

5. DISCUSSION

This section must begin with a precautionary note. Long--term documentary studies cannot, by definition, be expected to yield convincing proofs within one year of their initiation. Instead, they provide tantalizing glimpses of what might, eventually, be proved, given sufficient empirical evidence. Dr. Gene Likens, one of the founders and directors of the 20-year old Hubbard Brook Ecosystem Study in New Hampshire, U.S.A. (Bormann and Likens 1979) has often emphasized[a] that short-term fluctuations may be erroneously interpreted as long-term trends unless a study is continued long enough to verify these inferences. Hence it would be premature to attach much significance to what has thus far been observed in the eight SEADYN reference stands. The sections that follow contain some preliminary inferences, some proposals for future research, and, implicitly, some reflections on the status of this two-year old project.

5.1 SOME TENTATIVE INFERENCES

The following, very preliminary, inferences may or may not eventually prove to be important conclusions of this project. No priority is intended by their numerical order.

(1) Forest ecosystems on the *Picea glauca* [*Populus tremuloides*] habitat type are much more 'dynamic', in terms of seasonal and intraseasonal variations of vascular plant shoot cover, than are those on the *Picea glauca* [*Pinus banksiana*] and *Picea mariana* [*Larix laricina*] habitat types. This inference accords with the earlier work of Korchagin and Karpov (1974) in Eurasian taiga forests, where pure coniferous stands were found to be more 'conservative' than mixed stands.

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[a] For example, in his lecture titled "An ecosystem approach to nutrient cycling and forest management," given to the Zoology Department Seminar, University of Alberta, on 2 April 1982.

(2) Significant changes in the abundance of dominant vascular plant species can occur from year to year, i.e., annually, in both 'mature' as well as young forests.

(3) During the course of plant succession the total cover of feather mosses increases at the expense of other terrestrial bryophyte and lichen growth-forms on all three habitat types.

(4) In early stages of plant succession the total cover of herbaceous and broad-leaf deciduous vascular plants increases, but in later stages they decrease such that needle- and broad-leaf evergreen vascular plants dominate the subclimax and climax forests on all three habitat types.

(5) Weather fluctuations during the snow-free season are correlated with, and probably control, the relative growth and senescence rates of vascular plant species, and therefore also the structural dynamics of the plant community.

(6) One herbivore species (e.g., Snowshoe Hare, Tent Caterpillar), if plentiful, can have dramatic and possibly long--lasting effects, both direct and indirect, on the species structure and dominance hierarchy of a plant community by reason of its preferential feeding behavior, unless the community is notably lacking in food species.

(7) Weather conditions must be favorable to permit massive outbreaks of herbivore populations such as that of Tent Caterpillar in the SEADYN study area in the summer of 1981.

(8) Plant species vary widely in their ability to resist and/or recover from environmental perturbations such as the late spring and late summer droughts and the defoliation impact of the Tent Caterpillar in 1981.

(9) Of the 19 major hypotheses postulated in the Introduction (section 1.3.1) nos. 1,2,3,10,11,12,13,14,15 are supported and no. 9 is not supported by data so far obtained and synthesized.

5.2 ALLOMETRIC ESTIMATION OF SHOOT BIOMASS AND LEAF AREA

Of key importance to the achievement of several major objectives of this project (see section 1.3.2) is the development of a comprehensive set of species-specific, allometric prediction equations for the accurate estimation of above-ground biomass and leaf area from shoot cover estimates made in the reference stands (see sections 3.5 and 4.7). The results obtained so far for understory vascular plants are very encouraging, and we are convinced that the method is sound. The sequential procedure will be repeated in 1982 to test hypothesis no. 9 (section 1.3.1) and to obtain additional data on species inadequately sampled in 1981.

In a study of ground vegetation biomass, production, and efficiency of energy utilization in northern Wisconsin forest ecosystems, Zavitkovski (1976) showed that net annual production in the vascular understory was essentially equal to the end-of-season standing crop biomass (including both living and dead material). If this relationship is true for boreal ecosystems in the SEADYN study area, then end-of-season harvests in plots outside the reference stands may be initiated in future years.

As noted in section 3.5.3 no attempt was made to estimate leaf area, leaf biomass or total above-ground biomass of tree populations in the eight reference stands in 1981. We hope that these attributes can be estimated in 1982 after stem mapping is completed (section 4.8) and appropriate prediction equations are developed or found in the forest mensuration literature.

5.3 DYNAMICS OF DETRITUS AND DEAD WOOD PRODUCTION

Observations on the structural dynamics of plant populations and communities based solely on living tissue (e.g., by means of monthly surveys of live shoot cover) provide no explicit record of the fate of the dead material (including leaf, twig, and branch detritus, and dead trees) which is also being produced. When above-ground tissue mortality rates exceed tissue growth rates, shoot cover inevitably decreases in proportion to the differential or net loss of

live tissue. But how much of this net loss is accountable to herbivore activity, i.e., consumption of living tissue?

The allocation of net tissue loss to actual herbivore use and potential detritivore use can be quantitatively assessed in several ways, e.g.: (1) measure detrital production directly using traps or harvests from plots; (2) measure loss of leaf tissue to herbivores by determining leaf area losses on partially consumed leaves on collected specimens; or (3) measure the loss of whole leaves and shoots to herbivores on number-tagged plants in the field. In 1982 direct measurements of detrital production will commence in the eight reference stands, so that real data on the fate of lost tissue will begin to accumulate (see also 5.2). Samples of the detritus will be preserved for laboratory analysis (e.g., energy, protein and nutrient content).

The standing crop and annual production of living and dead wood in tree size-classes in the reference stands will be assessed from stem map data. The above-ground bole, bark, branch, twig and leaf fractions of living and dead trees can be estimated from age- and size-structure data on live, dead-standing and dead-down trees (e.g., Table 9, p 113) in combination with allometric formulae available from the forest mensuration literature. In 1982 estimates of the age-structure of tree populations in the reference stands will begin (see major objectives no. 11 in section 1.3).

5.4 RADIAL GROWTH OF TREES

Starting in May of 1982 Fritts dendrographs will be mounted on trees of the same and different species in several reference stands in order to monitor diurnal, intraseasonal and seasonal variations in tree diameters in relation to atmospheric and soil environmental conditions. These data will permit comparisons of radial growth in trees of differing size-classes, including dominant and suppressed individuals, with other kinds of growth already being monitored (e.g., leaf area, height) in the reference stands.

Although tree mortality is occurring as part of the normal thinning process in all stands, mortality rates are much higher in some stands than others, both in terms of tree density and tree biomass. We would like to know when trees die and why, as part of our study of tree population dynamics (see sections 3.6 and 4.8), as well as of dead wood production (see section 5.3 above). For example, was the death rate of *Populus tremuloides* trees in reference stand no. 5 constant throughout 1981, or did more trees die after defoliation by Tent Caterpillar, or after the late summer dry period, or during the winter? The diurnal cycle of transpiration peaks and lows in living trees is known to be visible on the dendrograph chart as increases and decreases in trunk diameter. Coupling these data with phenological observations on the dendrograph trees will help us document growth, senescence and death of trees in relation to external stresses.

5.5 IMPORTANCE OF BRYOPHYTES AND LICHENS

The quantitative and ecological importance of terrestrial bryoid and epiphytic lichen communities in the Boreal Taiga Biome has long been recognized (e.g., La Roi and Stringer 1976), and the data presented in this report strongly reinforce this assertion (cf. Tables 5 and 6). Wildlife forage assessments in the Boreal Taiga, however, usually emphasize vascular plants and neglect bryophytes and lichens, except when Caribou or Reindeer ranges are involved (e.g., Scotter 1963, 1965).

Terrestrial bryoid communities in older reference stands of all three habitat types in this project are dominated by feather mosses (e.g., *Pleurozium schreberi, Hylocomium splendens*) (Tables 5 and 6). In contrast, younger stands on the *Picea glauca* [*Pinus banksiana*] habitat type are dominated by fruticose, caribou lichens e.g., *Cladina mitis*); on the *Picea glauca* [*Populus tremuloides*] habitat type by bark and wood mosses (e.g., *Brachythecium salebrosum*); and on the *Picea mariana* [*Larix laricina*] habitat type by hygrophilic, brown mosses (e.g., *Tomenthypnum nitens*) and peat mosses (e.g.,

Sphagnum nemoreum). What factors are responsible for these dramatic shifts in the species structure of bryoid communities during plant succession, and the convergence on feather mosses?

In 1983 we will begin to deploy some proven and some new methods for the measurement of vegetative and reproductive phenodynamics of terrestrial bryophytes and lichens in the reference stands. We shall also begin to study the epiphytic lichen communities, since their contribution is significant as well.

5.6 INFLUENCE OF HERBIVORES

A large Snowshoe Hare population in the study area caused considerable damage to shrub and immature tree populations during the relatively mild winter of 1980-81. By selectively browsing and girdling its preferred food species (e.g., *Larix laricina, Betula pumila* and *Salix pedicellaris*) and avoiding others (e.g., *Picea mariana* and *Ledum groenlandicum*, all in stand no. 7), this herbivore significantly affected the species structure and dominance hierarchy of the vascular plant communities of several stands. Populations of some shrubs (e.g., *Amelanchier alnifolia* and *Prunus pensylvanica* in stand nos. 1 and 2) produced very few flowers in 1981 because their floral buds, which are formed the previous summer, were almost completely eaten by the hares.

Weather conditions in the study area during the winter of 1980-81 and spring of 1981 permitted an explosive outbreak of the Tent Caterpillar population in late May. Reference stand nos. 3, 5, and 6 supported much larger caterpillar infestations than the other five stands and were, consequently, much more affected by their feeding activities. As shown in section 4.5 the shoot cover of preferentially defoliated species (e.g., *Populus tremuloides, Viburnum edule*, and *Cornus canadensis* in stand no. 5 (Figure 5)) was greatly reduced by the larvae of this insect. Here the immediate rather than delayed (as with Snowshoe Hare) result of the herbivore activity was a dramatic change in the total leaf area of the plant community, with preferred species falling and unused species rising in relative shoot cover.

The ability to produce new shoots and leaves varies greatly among the browsed and grazed species. Hence the species structure and dominance hierarchy of stands changed again as some species recovered more quickly than others after herbivore use ceased.

The possible implications of these intense pulses of feeding activity by single herbivore species are fascinating to comtemplate. It is possible that such herbivores may influence both the direction and rate of plant succession in the reference stands, e.g., by favoring the growth of *Picea glauca* while *Populus tremuloides* is defoliated in reference stand nos. 5 and 6.

We shall see if Snowshoe Hare and Tent Caterpillar populations repeat their 1981 performances in future years, or if other herbivore species might play similar, though less dramatic, roles. By 1984 we hope that animal population and community ecologists will begin complementary studies of consumer trophic levels in the eight ecosystems, observing the abundance and behavior of herbivore, nectivore (i.e., pollinator), detritivore, and carnivore species.

5.7 PERMANENT PLOTS AS ECOLOGICAL MONITORING SYSTEMS

As pointed out in the Introduction (section 1.1) the possibilities of using the whole plant community as a sensitive, integrated ecological monitoring tool are very promising, and deserve to be explored just as soon as the necessary baseline information on 'normal behavior' is available. However, unless natural dynamic variations (e.g., intraseasonal, seasonal, annual and successional) in the composition, structure, and function of the plant community are taken into consideration, any attempt to use the plant community as a reliable indicator of environmental degradation is doomed to fail.

Like any scientific instrument, the plant community must be 'calibrated' before measurements made with it can be interpreted with confidence. The ecological monitoring research in progress in the Hondo - Lesser Slave Lake study area is intended to provide, *inter alia*, some of the necessary calibration inputs that will be needed

to use permanent plots for the detection and assessment of atmospheric pollutants and pollution effects in the Boreal Taiga Biome of western North America, including *Pinus banksiana* plots in the Athabasca Oil Sands area of northeastern Alberta (La Roi and Ostafichuk 1982).

Observations on herbivore impact (see section 5.6 above) in the eight reference stands strongly support the hypothesis that different stages of plant succession on the same habitat type are not equally sensitive to environmental perturbations. We predict that this hypothesis will be upheld when atmospheric pollution effects are studied along successional gradients in the Athabasca Oil Sands area. It is therefore entirely possible that the normal rate, sequence and end-point of plant succession will be significantly altered by changes in the composition of the atmosphere (e.g., CO_2, SO_2, NO_x, heavy metals). In a study of computer-simulated forest response to chronic air pollution stress, West et al. (1980) classified species as sensitive, intermediate or resistant to pollution-caused growth reduction, then observed forest succession for periods as long as 500 years. They found that normal succession patterns were significantly altered, largely due to pollution effects on the competitive abilities of individual plant species. We anticipate that similar alterations will be imposed on successional trends by atmospheric pollution in the Boreal Taiga Biome. Long-term studies in permanent plots should enable us to detect and evaluate such alterations, hopefully before they become irreversible.

5.8 POLLUTION MONITORING STATIONS NEEDED

All of the meteorological instruments thus far put into operation in the study area are designed to measure natural atmospheric variables (e.g., temperature, humidity, precipitation, solar radiation, wind). One of the basic functions of the Hondo - Lesser Slave Lake reference stands is to provide baseline information on the structural dynamics and other functions of natural ecosystems in a clean airshed, i.e., one in which concentrations of atmospheric contaminants are negligible if not nil. Although we have no evidence

to challenge this assumption, we think the null hypothesis should be rigorously tested. To do this we recommend installation of standard pollution monitoring instruments at the Hondo and NW recording stations, where they can be operated for the balance of the five-year period. We would also welcome temporary deployment of more sophisticated air sampling instruments whenever these are available, hopefully at suitable intervals during the annual cycle of seasons. Given information from these instruments, the study area's suitability as a 'control area' for comparison with ecologically analogous ecosystems in the Athabasca Oil Sands area of northeastern Alberta can be determined.

5.9 CONTROLLED BURN PROPOSED

At the present time there are no reference stands in very recently burned areas of the three habitat types in this project. The youngest stand (no. 1) originated after a fire in 1939 (Table 3). Hence we have no sources of structural dynamics data from very early stages of succession, and this is most unfortunate, because some of the most critical and rapidly unfolding events occur within the first few years after fire. We therefore advocate a controlled and documented burn of a small area (3-5 ha) of mature *Pinus banksiana* forest on aeolian sand in the study area in 1983, after careful selection and description of a suitable reference stand in 1982. By 1983 the project should be running smoothly enough to accommodate the increased work load posed by a new reference stand without a quantum increase in project costs. Fire specialists of several governmental agencies and universities would have to approve, plan and execute the controlled burn if this proposal is to be implemented.

5.10 WINTER STUDIES NEEDED

Most of the time and energy expenditures in this project have thus far been concentrated in the 'snow-free season', which lasts for about six months in the study area. We do hope to be able to assess changes in the attributes of plant populations and

communities that occur during the winter half of the annual cycle by comparing reference stands immediately before and after the appearance and disappearance of the winter snowpack. But we also need to know more about the structural dynamics of the snowpack itself, how it develops, how it varies in physical properties in both spatial and temporal dimensions in the reference stands, how much of it is retained and vaporized by the system compared with surface runoff and groundwater losses, etc.

Do different successional stages on the same habitat type vary significantly in terms of these winter snowpack properties? For example, do older stands melt out earlier or later than younger stands?

At present we rely upon winter weather data from the Slave Lake and Athabasca meteorological stations and do not operate the Hondo and NW stations in winter. In 1982 we will install a Sacramento totalizing snow gauge either at Hondo or in the nearby town of Smith (10 km north of Hondo) and obtain readings from it at monthly intervals during the winter season.

There is clearly a need for studies of animals and plants above and beneath the snow in the reference stands during the winter season.

5.11 OTHER RESEARCH IN THE EIGHT REFERENCE STANDS

The seasonal dynamics of wood decay fungi in dead and down boles of *Picea glauca* and *Populus tremuloides* in reference stand nos. 5 and 6 is currently being investigated by Dr. Lorene Kennedy, Department of Botany, University of Alberta.

A two-year Ph.D. study of the distribution and development of root systems in relation to succession, moisture regime, and nutrient regime in experimental plots adjoining the eight reference stands was initiated in 1981 by Mr. Wayne Strong, Department of Botany, University of Alberta.

A two-year Ph.D. study of total nitrogen and its allocation among available and unavailable forms in living plant tissue, litter

fall and humus along a successional gradient using the four reference stands on the *Picea glauca* [*Pinus banksiana*] habitat type will be initiated in 1982 by Mr. James Fyles, Department of Botany, University of Alberta.

A Botany Honors study of aspects of the ecological life history and population ecology of *Aralia nudicaulis* in reference stand nos. 2, 3 and 4 was initiated in 1981 by Mr. Larry Flanagan, Department of Botany, University of Alberta.

A study of the contemporary pollen rain from regional and local sources will be initiated in the reference stands in 1982 by Dr. Charles Schweger, Department of Anthropology, University of Alberta.

A study of the winter snowpack in the eight reference stands will be initiated in 1982 by Mr. Peter Kershaw, Department of Geography, University of Alberta.

The seasonal dynamics of the avifauna in the eight reference stands is being investigated by Mrs. Nancy La Roi, Department of Botany, University of Alberta. She is also monitoring the activities of Snowshoe Hare populations by means of fecal pellet counts in permanent microplots.

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7. APPENDIX

7.1 ANNOTATED LIST OF COLOR SLIDES

The 60 slides listed below are arranged in three groups. The first group (nos. 1 to 40) consists of photographs of the eight reference stands taken during the monthly surveys on an opportunistic basis (see section 3.8), with five slides for each reference stand. The second group (nos. 41 to 50) consists of oblique, closeup photographs of two microplots from fixed tripod positions in June, July, August, September, and November 1981 (see sections 3.3.2 and 3.8). The third group (nos. 51 to 60) consists of photographs of instrumentation, field observations in progress, and the Hondo Research Laboratory. All dates are 1981.

Slide No.	Reference Stand No.	Date	Annotation
1	1	12 May	Lateral view from SW corner, before new shoots are visible. *Arctostaphylos uva-ursi* and *Cladina mitis* co-dominate the ground surface in this young *Pinus banksiana* woodland.
2	1	11 Jun	Lateral view in early June when foliage of forbs (e.g., *Maianthemum canadense*) and shrubs (e.g., *Rosa acicularis, Vaccinium myrtilloides*) is young and bright green, and lichens are less prominent.
3	1	14 Jul	Closeup of the two most abundant evergreen, broad-leaf dwarf shrubs, *Arctostaphylos uva-ursi* and *Vaccinium vitis-idaea* and the fruticose lichen, *Cladina mitis* in mid-July. Note young and old leaves of the two shrubs.
4	1	24 Sep	Lateral view in late September when foliage of *Rosa acicularis* and *Vaccinium myrtilloides* has turned yellow, but hard, killing frosts have not occurred. Note the patches of brown needles in the pine canopy cf. slide nos. 1 & 2.
5	1	5 Nov	Closeup of ground surface in late fall with copious pine needles and evergreen shrubs and graminoids (*Carex umbellata*). Compare foliage color with slide no. 3.

Annotated List of Color Slides Continued

Slide No.	Reference Stand No.	Date	Annotation
6	2	13 May	Lateral view of a relatively open area of the stand with scattered mature pines and very prominent *Arctostaphylos uva-ursi* and *Cladina mitis* mats. Note accumulations of needles under pines.
7	2	14 Jul	Mid-summer phenology of an area where the tall shrub, *Alnus crispa*, is present under the pine canopy. Associated with the green alder are *Aralia nudicaulis*, foreground, and feather mosses (see slide no. 8); lichens are less abundant here than in more open areas (above).
8	2	14 Jul	Closeup of feather moss carpet dominated by *Pleurozium schreberi*, with typically mottled leaves of the root parasite, *Geocaulon lividum*, under a green alder canopy in mid-summer.
9	2	24 Sep	Lateral view of central max-min thermometer area in autumn. Note yellowing leaves on deciduous shrubs and the *Picea glauca* transgressive growing in the *Alnus crispa* bush, where conditions may be more mesic and protected.
10	2	24 Sep	Closeup of late-flowering *Erigeron glabellus*, multi-colored leaves of *Solidago decumbens* rosette, still green leaves of *Vaccinium myrtilloides* (bottom-center) and evergreen *V. vitis-idaea* (bottom-left) in the lichen mat.
11	3	13 Jun	Closeup of Tent Caterpillar larvae consuming new leaves of *Alnus crispa* in early summer. The alder population in this stand is larger and was more defoliated than the one in stand no. 2 (cf. slide no. 7).
12	3	14 Jul	Lateral view of abundant *Aralia nudicaulis* in hummocky feather moss carpets beneath defoliated green alder canopy in mid-July. New leaves developing on alder, but total cover never attained the values measured in 1980.

Annotated List of Color Slides Continued

Slide No.	Reference Stand No.	Date	Annotation
13	3	14 Jul	Closeup of *Cornus canadensis, Linnaea borealis, Maianthemum canadense, Rosa acicularis, Vaccinium myrtilloides* and new shoot of *Aralia nudicaulis* in moss carpet dominated by *Pleurozium schreberi* and *Ptilium crista-castrensis.*
14	3	22 Sep	Closeup of senescing *Epilobium angustifolium, Cornus canadensis* and dead *Maianthemum canadense* with still green *Rosa acicularis, Elymus innovatus* and some shoots of *Cornus canadensis* with evergreen *Linnaea borealis* in a moss carpet littered with pine needles in fall.
15	3	5 Nov	Lateral view in late fall. Note young *Picea glauca* on right, hummocks covered with feather mosses, and number tag on pine right of center.
16	4	11 May	Lateral view of large standing and fallen *Picea glauca* trees near the center of the stand in early May. Note feather mosses (mostly *Hylocomium splendens, Pleurozium schreberi,* and *Ptilium crista-castrensis*) on forest floor and logs.
17	4	11 May	Small *Abies balsamea* girdled by Snowshoe Hare in late winter. Only the smaller size-classes of balsam fir were used, and many small trees were not used in 1980-81.
18	4	13 Jul	Lateral view of deadfall area with root wad visible in left background. Note the low cover of understory vasculars, the high cover of bryophytes, and the new leaf cohorts (light green) on the *Abies.*
19	4	18 Aug	Lateral view of an area free of deadfall with several small *Abies balsamea* saplings scattered around an old *A. balsamea* (right) and *Picea glauca* (center), and virtually no understory vascular plants in the continuous feather moss carpet.

Annotated List of Color Slides Continued

Slide No.	Reference Stand No.	Date	Annotation
20	4	24 Sep	Closeup of feather moss carpet in which the *Hylocomium splendens* fronds below the knife are not yet fully expanded, perhaps because the summer was very dry? Note senescing *Viola renifolia* (yellow leaves on right), partially eaten *Cornus canadensis* leaves (right of knife), and dead leaves of *Maianthemum canadense*.
21	5	11 May	Closeup of mixedwood forest floor with matted *Populus tremuloides* leaf litter, evergreen forbs (*Linnaea borealis, Pyrola asarifolia, Cornus canadensis, Mitella nuda*) dominant before emergence of herbaceous forbs in early May. Note small patches of moss (*Brachythecium salebrosum*) in areas of raised micro-relief where smothering by leaves is less.
22	5	12 Jun	Vertical-up view of *Populus tremuloides* canopy after total defoliation by the Tent Caterpillar in early June. When the aspen leaf resource was depleted, the larval population descended into the understory and attacked preferred food species there.
23	5	12 Jun	Lateral view of rich shrub-herb understory beneath mixedwood canopy before appreciable defoliation of the dominant shrub (*Viburnum edule*) has occurred. The tall forb *Mertensia paniculata* is in flower (blue-purple) but most of its plants are vegetative in a given year. Note 50-cm 'stockings' of mosses on *Populus tremuloides* trunk bases.
24	5	17 Aug	Closeup of understory vasculars in mid--August. Visible are the evergreen species visible in slide no. 21 plus *Aralia nudicaulis, Aster ciliolatus* (top-center in flower), *Rubus pubescens, Galium boreale, Ribes triste, Viburnum edule, Elymus innovatus*, all of which are beginning to turn yellow as the drought continues and summer wanes.

Annotated List of Color Slides Continued

Slide No.	Reference Stand No.	Date	Annotation
25	5	4 Nov	Lateral view of the forest in late fall. Note extensive dead and down trees of *Populus tremuloides* which undergo relatively rapid decomposition. Leaf litter from *Populus tremuloides* is much less abundant cf. 1980 because of Tent Caterpillar activities and the inability of *P. tremuloides* to produce a full second leaf canopy in 1981.
26	6	11 May	Oblique view of mature mixedwood tree stratum co-dominated by *Picea glauca* and *Populus tremuloides*, the former now taller than the latter. A lower tree canopy (not visible) is forming in this forest, dominated by *Abies balsamea*.
27	6	11 May	Lateral view of relatively dormant understory in early May, with young *Abies balsamea* visible at right and background, and mosses visible through detritus on ground.
28	6	12 Jun	Lateral view of lush new foliage of rich shrub-herb understory. The most prominent vasculars are *Lonicera involucrata, Aralia nudicaulis, Mertensia paniculata, Rosa acicularis*. Note new leaf cohort on *Abies balsamea* at left.
29	6	17 Aug	Closeup of a feather moss carpet dominated by *Pleurozium schreberi* in an area where shrubs and tall forbs are less abundant cf. slide no. 28. Visible are *Mertensia paniculata, Linnaea borealis, Aralia nudicaulis, Cornus canadensis, Trientalis borealis, Rosa acicularis, Galium triflorum, Elymus innovatus, Actaea rubra, Petasites palmatus* and a sucker of *Populus tremuloides*.
30	6	23 Sep	Lateral view of forest in autumn color. No hard frost had occurred yet.

Annotated List of Color Slides Continued

Slide No.	Reference Stand No.	Date	Annotation
31	7	13 May	Lateral view of relatively dormant *Picea mariana* forest in early May. Numerous Snowshoe Hares were seen in this stand in late spring; they severely browsed the *Betula pumila* and *Salix* populations during the winter of 1980-81.
32	7	13 Jun	Closeup of *Salix myrtillifolia, Smilacina trifolia, Carex rostrata, Oxycoccus microcarpus, Ledum groenlandicum* in a *Sphagnum* hummock in early summer. Note newly formed and fallen *Ledum* leaves upper left.
33	7	15 Jul	Hare-browsed *Betula pumila* and *Salix pedicellaris* producing new branches near base of Coleman soil moisture/temperature station at SW corner of stand. Also visible are *Potentilla palustris, Andromeda polifolia, Smilacina trifolia* and *Carex diandra*, all rooted in a moss carpet dominated by *Tomenthypnum nitens*.
34	7	18 Aug	Oblique view of *Carex rostrata* tussocks and vigorously sprouting *Betula pumila* in a *Tomenthypnum nitens* hummock on left, and *Andromeda polifolia* growing in the *Sphagnum* hummock on right.
35	7	3 Nov	Lateral view of open area showing red *Sphagnum* hummocks and dead *Carex rostrata* tussocks in early November. The *Picea mariana* population has a clumped dispersion pattern in this area of the stand.
36	8	11 Jun	Lateral view of *Picea mariana* feather moss forest in early summer. Note luxurious development of the moss carpet, dominated by *Pleurozium schreberi*, and the very sparse understory vasculars.
37	8	11 Jun	Closeup of small remnant patch of *Sphagnum* in a relatively open area of the forest. The vasculars are *Rubus chamaemorus* (white flowers), *Smilacina trifolia, Ledum groenlandicum;* some *Pleurozium schreberi* at right of knife. Note hare pellets at lower left.

Annotated List of Color Slides Continued

Slide No.	Reference Stand No.	Date	Annotation
38	8	18 Aug	Oblique view of *Picea mariana* crowns in late summer. Note gap in upper portion of tree in center of photo; Red Squirrels harvest cone-bearing branches rather than individual cones in black spruce.
39	8	23 Sep	Lateral view of *Ledum groenlandicum* clone growing beneath an opening in the tree canopy. Note yellow and brown old leaves under laterally oriented green leaves on *Ledum* in fall season.
40	8	5 Nov	Closeup of *Ledum groenlandicum* with its leaves in the reflexed, winter orientation (cf. slide no. 39). As a result of this adaptation, estimates of shoot cover of *Ledum* on this date show a large decrease compared with September. Note floral bud on uppermost branch.

Slide No.	Microplot No.	Date	Annotation
41	2-7-H	18 Jun	*Cladina mitis* is the dominant lichen with *ca.* 70% cover. Other lichens present are *Cetraria pinastri, Cladonia coccifera, Cladonia gracilis, Cladonia multiformis, Cladonia cornuta, Cladonia pyxidata* for an additional 1.25% cover. The mosses include *Polytrichum juniperinum* and *Polytrichum piliferum* with a combined cover of only 0.1%. Note the lighter green of new growth of *Arctostaphylos uva-ursi*, the dominant dwarf shrub.
42	2-7-H	29 Jul	New growth on *Arctostaphylos uva-ursi* has now hardened off. Marked additional growth of *Solidago decumbens* left center.
43	2-7-H	26 Aug	*Maianthemum canadense* and *Rosa acicularis* (left and top) starting to turn yellow; August was very dry in 1981.

Annotated List of Color Slides Continued

Slide No.	Microplot No.	Date	Annotation
44	2-7-H	21 Sep	*Maianthemum canadense* and *Rosa acicularis* leaves no longer visible, and *Solidago decumbens* leaves dying back rapidly. *Anemone multifida* leaves at lower left yellowing. Recently fallen pine needles prominent.
45	2-7-H	4 Nov	All vascular plants in winter dormant condition. Pine needles even more abundant than in slide no. 44.

Comparing the June and November photos there appears to be an appreciable increase in *Arctostaphylos uva-ursi* cover. There is a possibility, judging from these photos, that much of the new growth of vascular plants was made early in the growing season, before the photo series began. Continuing photo documentation should provide answers to the above as well as a visual record of successional changes in this *Cladina mitis - Arctostaphylos uva-ursi* assemblage.

46	5-7-H	12 Jun	There are no lichens in this microplot. A scrap of *Usnea* is present as a displaced (fallen) epiphyte. The bryophytes include *Hylocomium splendens* (15%), *Pleurozium schreberi* (3%), *Brachythecium salebrosum, Eurhynchium pulchellum, Plagiomnium cuspidatum* (each 1%), and *Ptilium crista-castrensis* (0.1%). Prominent vasculars include *Aralia nudicaulis, Maianthemum canadense, Cornus canadensis, Linnaea borealis,* and *Viburnum edule* seedlings. At least two Tent Caterpillars are visible as well as caterpillar damage to some *Viburnum edule* leaves.
47	5-7-H	30 Jul	In addition to caterpillar damage there is hail damage evident in this photo.
48	5-7-H	25 Aug	Some of the vasculars are beginning to turn yellow; the very dry late summer may be partly responsible for this. There has been some extinction of *Brachythecium salebrosum* on the fallen log at right.
49	5-7-H	23 Sep	Most of the herbaceous forbs are either invisible or yellow/brown; as a result the evergreen forbs and mosses are more prominent in this autumn condition.

Annotated List of Color Slides Continued

Slide No.	Microplot No.	Date	Annotation
50	5-7-H	4 Nov	A light snowfall had lain here for about two weeks before melting off. Considerable breakdown of the fallen leaves has already occurred, especially those of *Populus tremuloides*. However, the general smothering effect on mosses is evident. The upper left is a small hummock which sheds fallen leaves to some extent and it is here that the mosses can survive. The forest floor will probably remain in this state as long as *Populus tremuloides* is a member of the tree stratum.

Slide No.	Date	Annotation
51	24 Sep	Hondo meteorological station in a clearing on a low hill to the south of the base camp. Visible are the Stevenson screen on right, rain gauge just to left of screen, and 3-cup anemometer at left. Actinograph has been removed from roof of the screen as of this photo date.
52	23 Sep	NE max-min thermometer station in reference stand no. 8. Taylor sixes type instrument is housed in an aluminum shield, facing north. On right is the plastic pipe containing wire leads from Coleman soil moisture/temperature sensors in soil profile.
53	13 May	Rain gauge located in open area to west of reference stand no. 2. Gauge is plastic, Tru Chek wedge design, with mineral oil to prevent loss by evaporation.
54	12 Jul	Wayne Strong in one of his seven soil pits located just west of reference stand no. 2. Pits were 1 x 1 m in area and 1 to 2 m deep, depending on profile depth. Coleman meter in foreground.
55	21 May	Robert Ellis and Larry Flanagan collecting, measuring, and field-pressing plant specimens next to reference stand no. 5 in late May.

List of Annotated Color Slides Concluded

Slide No.	Date	Annotation
56	31 Jul	Mike Ostafichuk (black hat) and Robert Ellis doing survey of microplots in reference stand no. 4 in mid-summer. The aluminum frame is positioned to the NE of the corner post making re-location easy; red flags keep staff away from microplots.
57	4 Nov	*Populus tremuloides* no. 750 located in reference stand no. 5. The aluminum tag is nailed to the tree with a zinc-coated nail, allowing space for several years of radial growth. Diameter measurements are made at tag height. Note fruiting body of *Phellinus tremulae* (formerly known as *Fomes igniarus*) on the trunk; this fungus causes heart rot of the aspen trees.
58	4 May	Two portable structures arriving at Hondo from the ATCO yard in Spruce Grove, Alberta. Each unit is 3.2 x 13.3 m in area; three units now constitute the buildings of the Hondo Research Laboratory: laboratory, dormitory, kitchen-diner--washroom.
59	5 May	Installation of septic system at Hondo. The site has very sandy soil with scattered *Pinus banksiana* trees.
60	22 May	View of Hondo Research Laboratory from the west in late May of 1981. Alberta Power pole in foreground. Each unit has a furnace supplied with propane from a central tank. There is an abundant supply of well water. There is a telephone. The Hondo Post Office is located 150 m east along the road. The base camp is far enough away from Highway No. 2 to permit sound sleep!

7.2 COLOR SLIDES

The 60 color slides supplied with the original set of reports are inserted in three clear plastic pages at the end of the report.

7.3 SAMPLE DATA SHEETS

Examples of four SEADYN data sheets and one computer output summary are given on the next seven pages as follows:

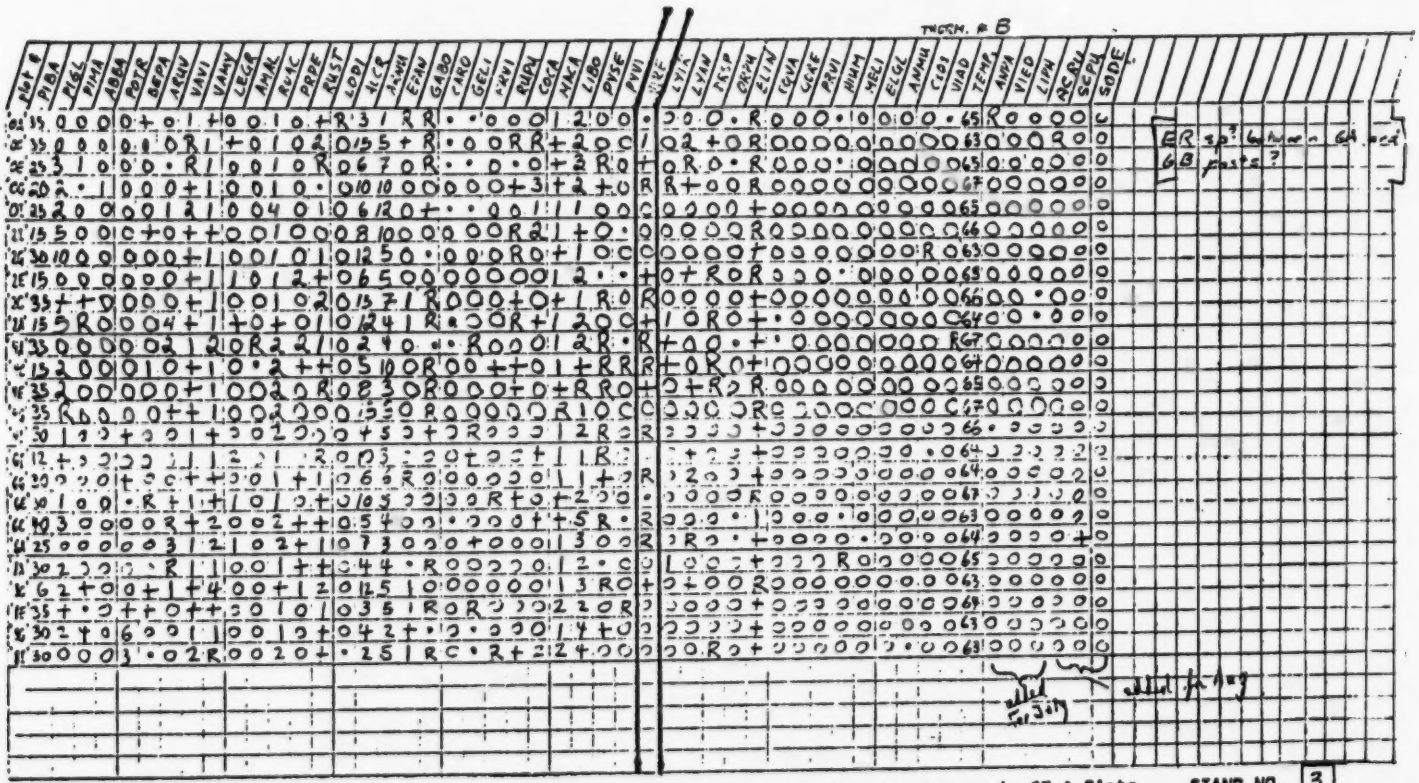
(1) Vascular shoot cover survey data sheet for reference stand no. 3, 16 August 1981.

(2) Stem map inventory data sheet for reference stand no. 3, July 1981.

(3) Shoot analysis data sheet for *Epilobium angustifolium* specimen no. SD-FLAN 349.

(4) Shoot analysis data sheet for *Arctostaphylos uva-ursi* specimen no. SD-FLAN 547.

(5) Computer output summary for vascular plant community in reference stand no. 3, 16 August 1981, using Lee (1982).



Center
MAY 94 | this 39 | Current 23 | 1645?

* counted in my subfile

SEADYN Reference Stand Vascular Survey in 25m² Plots STAND NO. 3

Please: use HB pencil; erase, don't overwrite;
for absent sp., code a zero,

Estimator: GHLR

Date: 16/Aug 1921
Recorder: [illegible]
page 1 of 1

Data entry done 26/2/1992
File name: GHLR:SS8T.V.ST25

SEADYN Reference Stand Stem Mapping STAND NO. 3

Observers: BL, PF; Recorder: LF. Date: 25 / June / 1981

All entries RE right-justified, w/o decimal points, w/ units as indicated.

Plot #[1]	Tag #	s[7]	DBH (.1")	Root Coordinates[2] N	S	E	W	D[3]	Fallen Stems Only[4] Leng[5] (dm)	Exit Coord[6] (dm) N	S	E	W
8 J	901	J	43	15			7	X					
8 J	902	J	92	15			21						
8 J	903	A	29	14		23		X					
8 J	905	J	38		16		4	X	49		25	0	
8 J	900	J	83		5		2						
9 A	943	J	43	5		12		X					
9 A	946	J	80	13			13						
9 A	942	J	81	22		9							
9 A	947	J	37		15		0	X	83		20	0	
9 A	945	J	78		15	23							
9 A	944	J	76		15	6							
9 B	941	J	43	13			9	X					
9 B	940	J	80	16			16						
9 B	939	J	77	11			11						
9 B	938	J	83	15			24						
? 9 C	936	J	64	10		5		X				0	15
? 9 C	937	J	39	17		7		X				0	9
9 D	935	J	98	6			15						
9 D	933	J	76		12	20							
9 D	934	J	84		12		84						
9 E	932	J		0			4	X		12			0
9 E	930	J	116	25			8						
9 E	929	J	66	15			17						
9 E	931	J	37		19		14						
9 F	928	J	65	3			3						
9 F	927	A	53	10			23						
9 F	923	W	25	25		6							
9 F	924	J	85		13	12							
9 F	925	J	77		3		20						
9 F	926	J	79		4		4						
9 G	922	J	90	12			11						
9 G	920	J	74		15		22						

1. Always enter the plot #
2. Enter distance from north or south boundary and distance from east or west boundary (i.e., 2 and only 2 coordinates on each line). If rooted on plot boundary, enter zero.
3. Enter "D" if dead, blank if living.
4. Leave blank if stem not deemed to have fallen.
5. Length of fallen stem from root to apex. Optional if apex in same plot as root.
6. Coordinates where fallen stem exited plot containing root, or the coordinates of the apex if apex in same plot as root. See 2, also.
7. Species codes. ABGRF, ABGRA, PSMEM, JUOCC, LOLAS, PIPOP, PIPOB, PIMO3

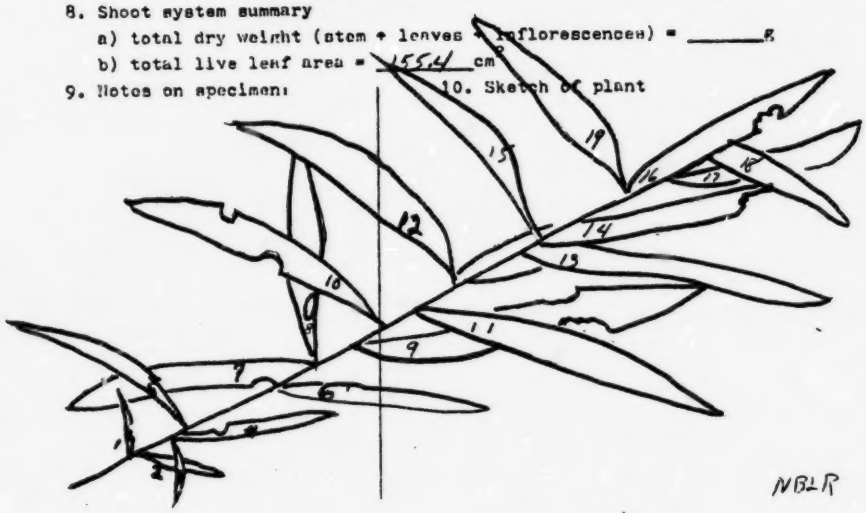
Plot #	Tag #	Comments

SHOOT ANALYSIS: FORBS Species FRAN Stand 5 Date 19 July 81
SEADYN Project Collection No. 517 Observer Flea

1. Intact shoot height before harvest = 97 cm
2. Intact shoot area, projected from above, = 85 cm^2
   a) crown area = _____ cm^2; b) % crown area occupied = ____%.
3. Basal diameter = 0.2 mm
4. Visible leaf count: mature = ____; immature = ____; total = 19.
5. Floral analysis a) number inflorescences = ____
   b) number flowers _____; c) number fruits = _____
   d) number aborted flowers/fruits = _____
   e) dry weight of floral material = _____ g
6. Leaf analysis (continue on reverse as required)

Leaf #	Lgth (cm)	Width (cm)	Area (cm^2)	% consumed	% dead	dry wt (g)
3	6	.9	4.0			
6	9.5	1.3	9.0			
9	10	1.3	8.0	15		
12	11.5	1.5	8.4	3.5		
15	11	1.4	11.5			

7. Stem analysis (minus inflorescences and leaves)
   total length = 15 cm
   total dry weight = 1.10 g
8. Shoot system summary
   a) total dry weight (stem + leaves + inflorescences) = _____ g
   b) total live leaf area = 155.4 cm^2
9. Notes on specimen:
10. Sketch of plant



NBLR

SHOOT ANALYSIS :
SHRUBS
SEADYN PROJECT

species= ARUV stand= 1 date= July 2018!
Collection no. 547 Observer L.F.

1. Intact shoot height before harvest= 17 cm
2. Intact shoot area, projected from above= 40 cm^2
   (a) crown area= _____ cm^2 (b) % crown area occupied= _____ %
3. Basal Diameter= 2.4 mm
4. Basal ring count= 13 rings
5. Visible leaf count: mature= _____; immature= _____ TOTAL= 59.
   $\bar{x}_A = 1.26$
6. Floral Analysis a) number of inflorescences= _____
   b) number flowers= _____ c) number fruits= _____
   d) number aborted flowers/fruits= _____
   e) dry weight of floral material= _____
7. Leaf Analysis (measured every leaf _____; Every 8th leaf)

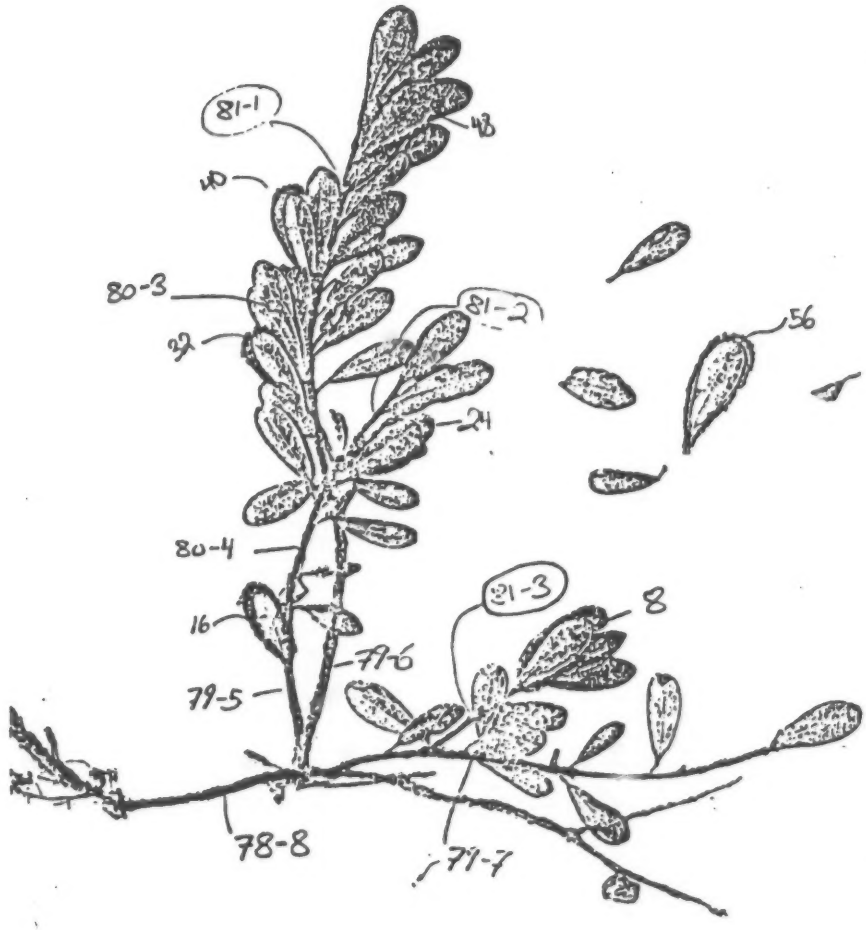
Leaf #	Lgth.(cm)	Wdth(cm)	Area (cm^2)	% Consumed	% Dead	Dry wt.(g)
8	2.0	0.8	1.4			
16	1.5	0.5	0.9			
24	1.9	0.8	1.4		11	
32	1.9	0.6	0.9			
40	1.9	0.6	0.9			
48	2.2	0.9	1.7		7	
56	2.2	0.9	1.6			

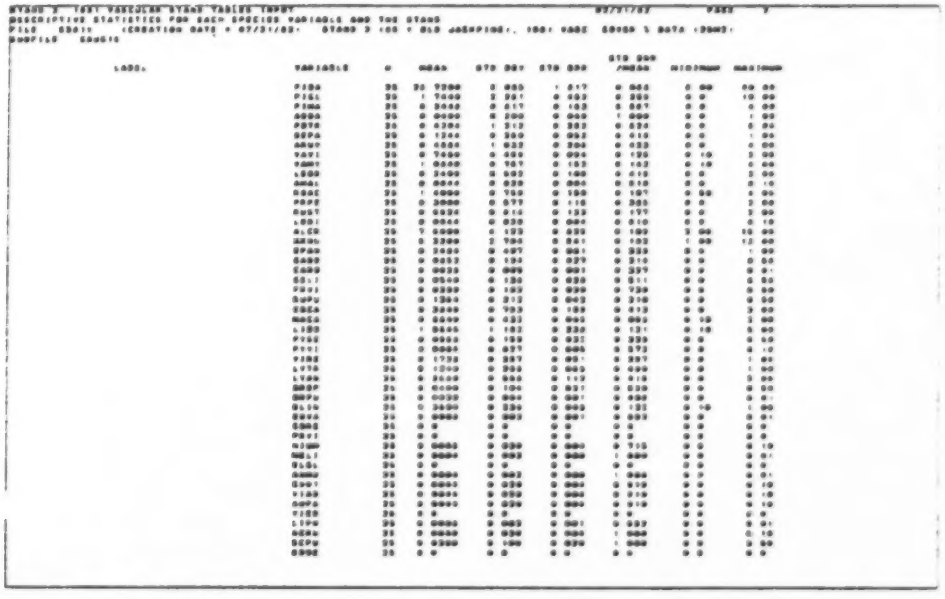
8. Stem Analysis

Segment#	mean diameter(mm)	Length(cm)	Dry wt (g)
S1-1	1.1	3.9	
S1-2	0.8	1.8	
S1-3	1.0	2.9	
S0-3	1.6	5.0	
S0-4	1.3	2.9	
S7-6	2.1	4.8	
S7-7	2.1	10.3	
S8-8	2.3	4.1	

9. Shoot System Summary
   a) total dry wt.(stems + leaves + Inflorescences)= _____ g
   b) total live leaf area= 34.2 cm^2
10. Notes on plant specimen:
11. Sketch of plant(show stem seg. #'s)

→ Q.F.


81-1
48
40
80-3
81-2
56
32
24
80-4
81-3
8
16
79-6
79-5
78-8
71-7



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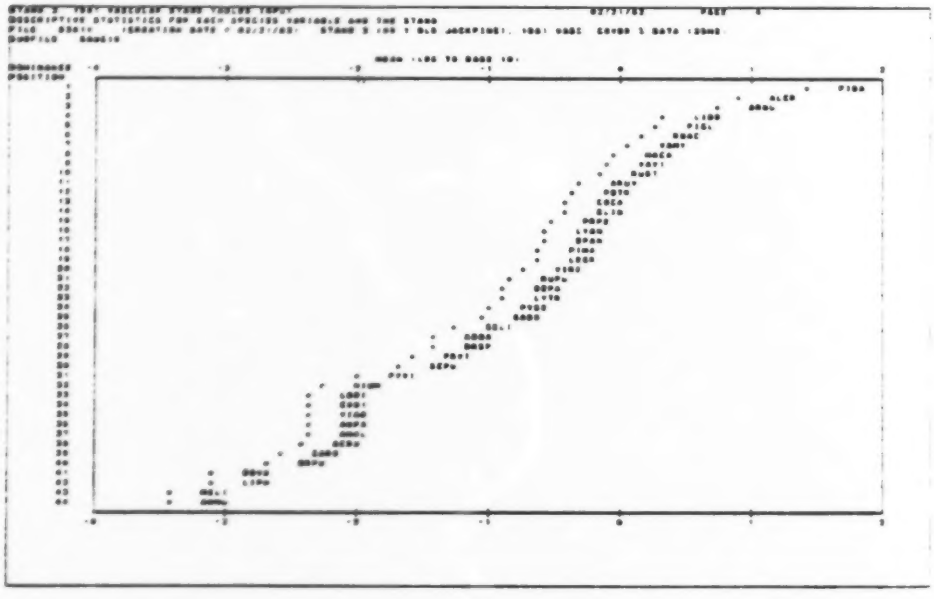

POOR

QUALITY

ORIGINAL